

FIGURE VII-4. SILVER CONTENT IN EFFLUENT—NO SILVER RECOVERY ON SOME FIX SOLUTIONS

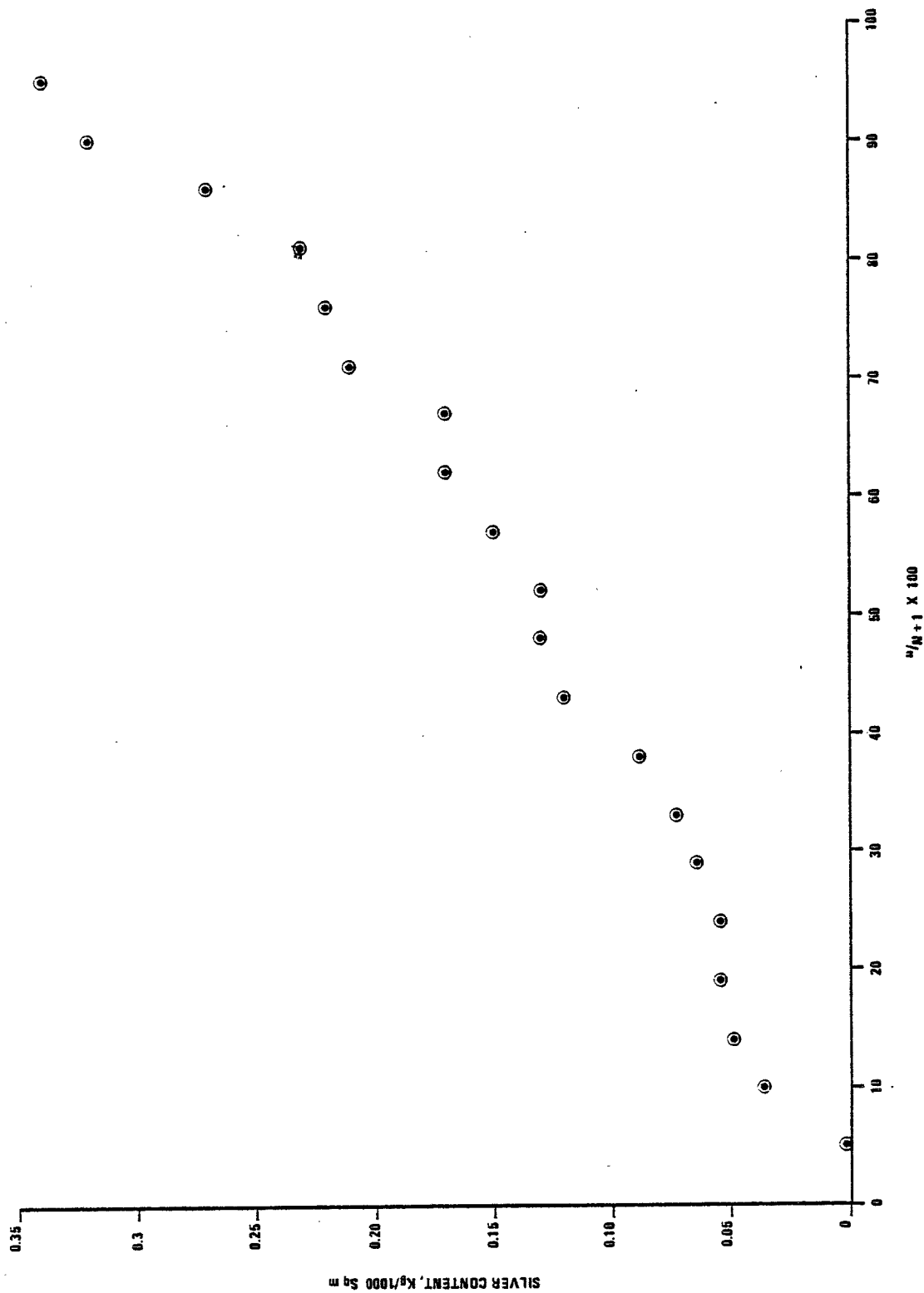


FIGURE VII-5 SILVER CONTENT IN EFFLUENT - SILVER RECOVERY ON ALL WASTE FIX

VII-14
196

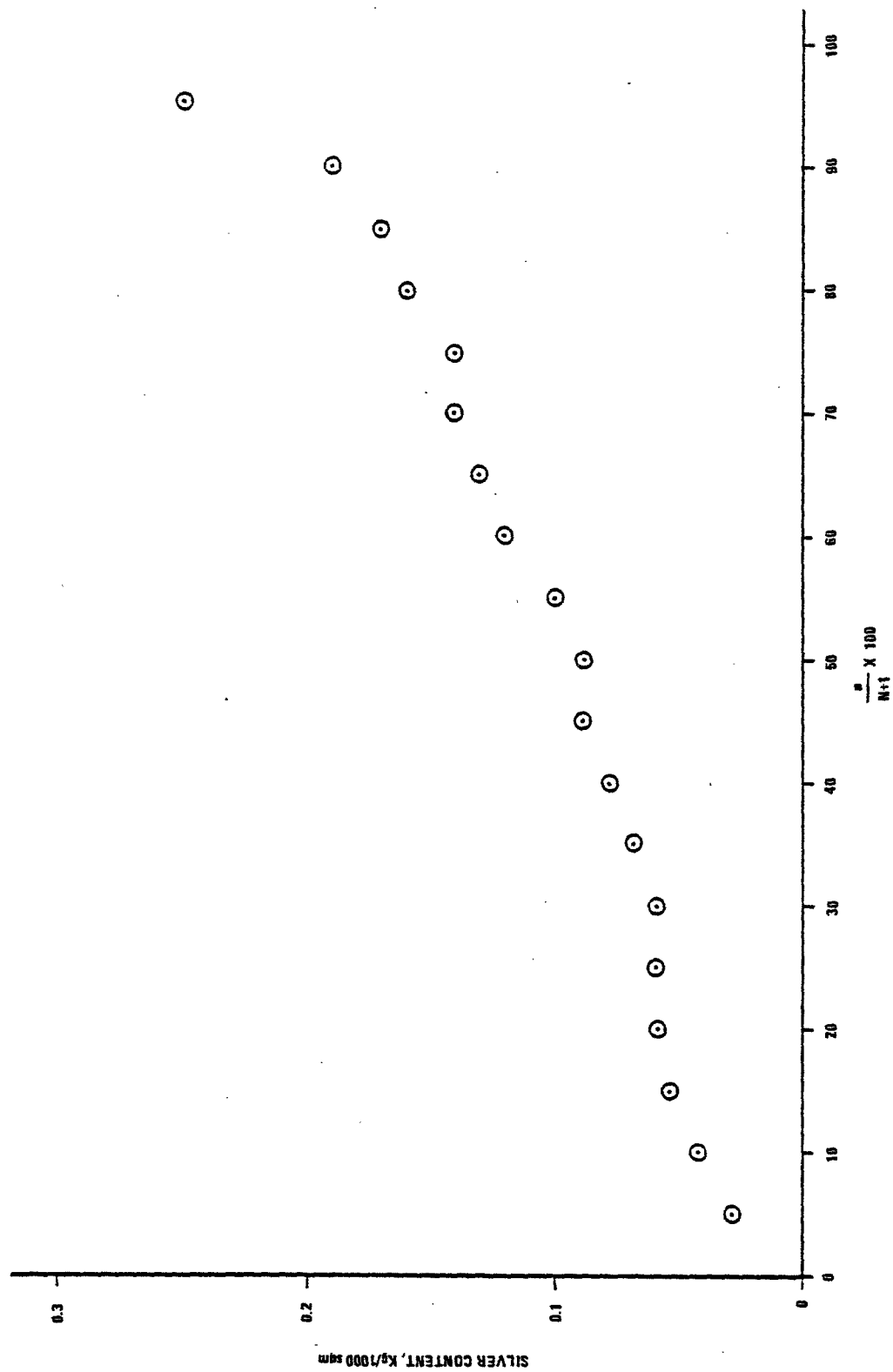


FIGURE VII-6 SILVER CONTENT IN EFFLUENT - WASTE FIX NOT IN SAMPLE

VII-15
197

TABLE VII-8
Results of Silver Recovery on Silver Content in
Plant Effluent - Conventional Silver Recovery on All Waste
Fix plus Additional Recovery By:

Ion Exchange on Wash Water Plus Wash Water Recycle

<u>Plant</u>	<u>Total silver load, kg/1,000 sq m (lb/1,000 sq ft)</u>
6208	0.048 (0.0098)

Precipitation Plus Reverse Osmosis Treatment of Wash
Water and Wash Water Recycle

7781	0.0088 (0.0018)
------	-----------------

Table VII-9 compares the efficiencies of individual silver recovery units used at some of the facilities. These data show the effects of specific treatments on individual wastewater streams. The operating conditions used for either the electrolytic or metallic replacement silver recovery processes will determine the efficiency of silver recovery. The efficiencies calculated for reverse osmosis are based on the incoming water versus the permeate. The concentrate solution from the reverse osmosis unit contains high concentrations of silver which should be recovered. The relative efficiencies of the various types of units are not directly comparable with each other because of the varying silver and other pollutant levels in the treated solutions.

TABLE VII-9
Effectiveness of Various Silver
Recovery Procedures

<u>Plant</u>	<u>Recovery Process</u>	<u>Concentrations of Silver Present, (mg/liter)</u>		<u>Removal Efficiency, Percent</u>
		<u>Influent</u>	<u>Effluent</u>	
6208	Ion exchange (wash water)	2.0	0.14	93
9061	Ion exchange (wash water)			
	Unit 1	0.74	0.04	95
	Unit 2	0.60	0.10	84
4550	Metallic Replace- ment	1,580	4.7	99.7
	Electrolytic (primary plus tailing)	576	21	98
7781	Reverse Osmosis (wash water)	68	14	79
	Chemical Precipi- tation (RO concen- trate plus waste fix)	57	0.08	99.9
2714	Reverse Osmosis (paper wash)	6.3	0.04	99
	Reverse Osmosis (film wash)	0.99	<0.02	98+

The relationship between the effluent concentration and the effluent amount for silver and the percent of production using ferricyanide bleach for total cyanide is shown graphically in Figures VII-7 and VII-8, respectively. The graphs show a poor dependency between concentration and amount for silver or between concentration and production percentage for total cyanide. Therefore, a concentration

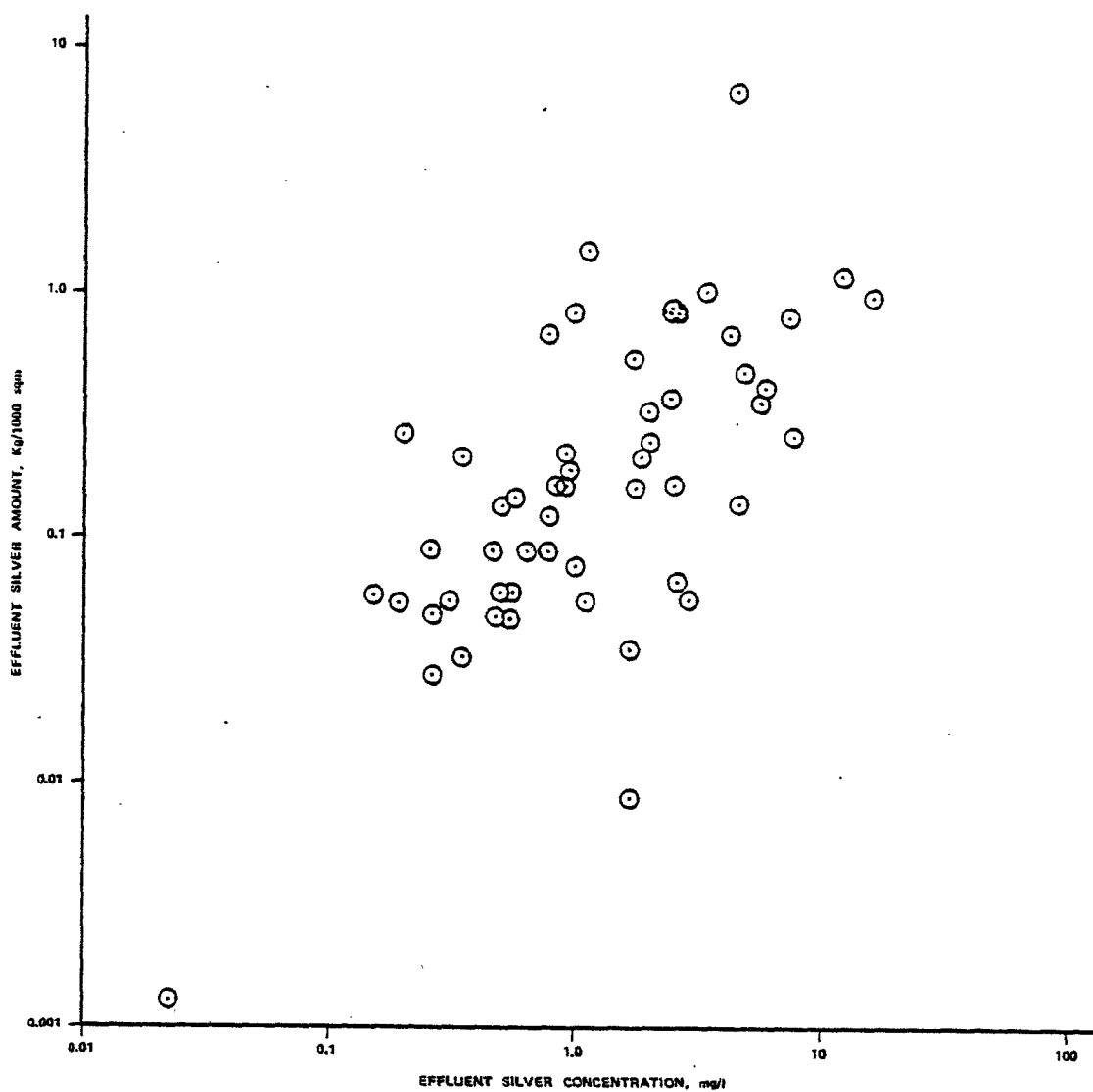
based limitation would not necessarily limit the amount discharged.

A "low-flow prewash" has been used on an experimental basis at plants 3630 and 6174 to allow conventional recovery of silver from after-fix wash water. The technique as described in Section III segments the after-fix wash tank into prewash and final wash tanks. The prewash tank receives the fix dragout and has a separate fresh water input and overflow. The water input flow is optimized depending on the rate of waste fix carry-in and its silver concentration and the final silver treatment level of the prewash. The benefits of using this system, based on theoretical calculations and the results from plant 3630, are shown in Table VII-10. These calculations were made using the following assumptions:

- (1) Paper wash rate = 5.7 liters/min
- (2) Silver concentration of normal paper wash = 6.1 mg/l
- (3) Bleach-fix silver concentration = 1,900 mg/l
- (4) The carry-over flow rate from the bleach-fix to the wash is calculated to be 0.018 liters/min

Plant 3630 installed a prewash system on a color paper processor. Silver was recovered from the prewash tank overflow with a conventional metallic replacement cannister. The results obtained from this system over a period of 145 days are summarized below and in Table VII-10.

Final wash flow - 5.7 liters/min
Silver concentration in normal paper wash -
1 to 5 mg/l
Bleach-fix silver concentration - 3,000 mg/l
The carryover flow rate from the bleach-fix
to the wash is calculated to be 0.018 liters/min
Silver concentration in final wash - 3.0 ± 2.5 mg/l



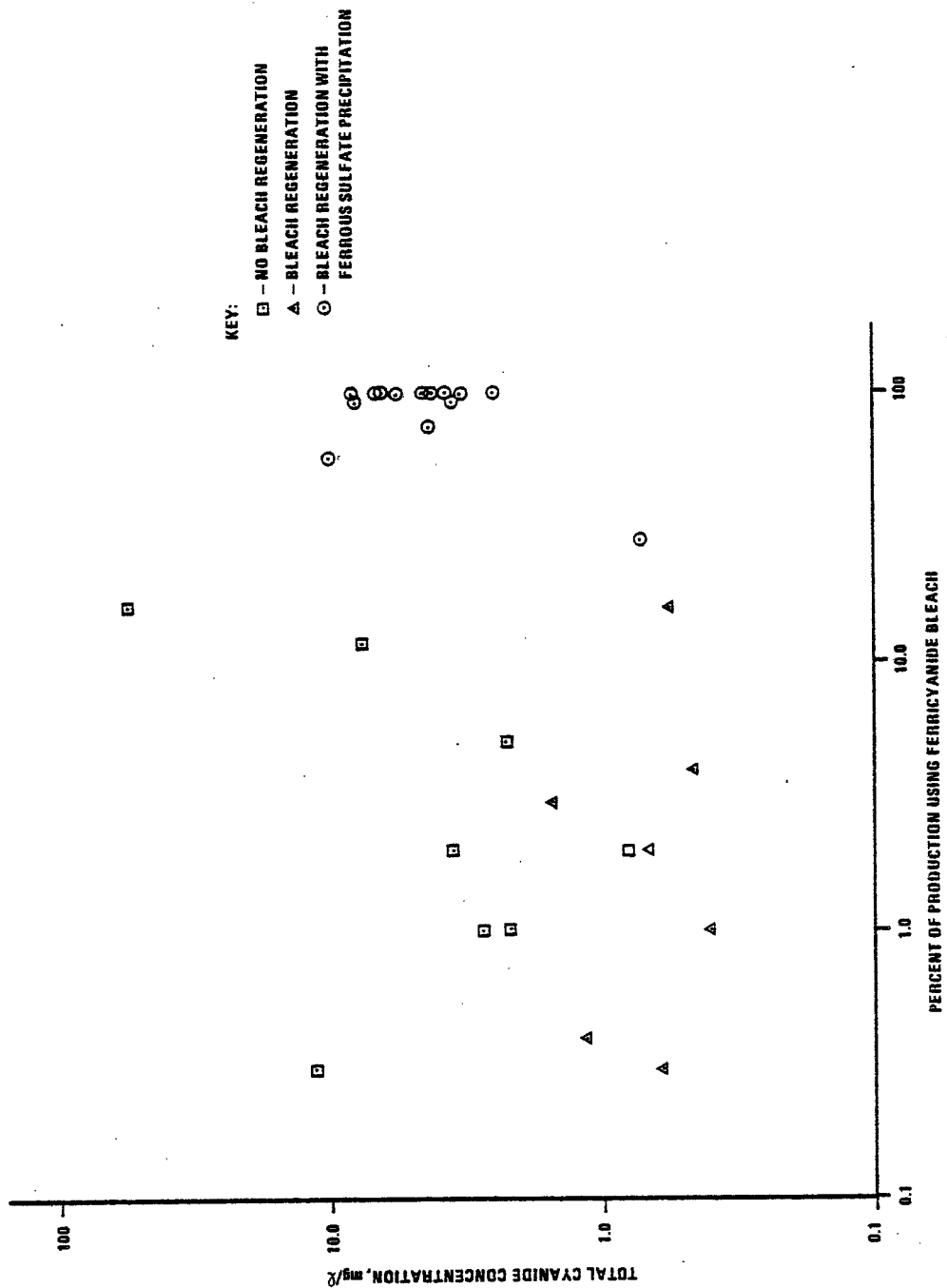


FIGURE VII-8 CYANIDE CONCENTRATION VS. PERCENT PRODUCTION USING FERRICYANIDE BLEACH

TABLE VII-10

Summary of Prewash Results

<u>CR*</u> <u>mg/l</u>	<u>CT**</u> <u>mg/l</u>	<u>Prewash Flow</u> <u>l/min</u>	<u>Percent</u> <u>Removal</u> <u>of Silver to</u> <u>Final Wash</u>	<u>Percent of</u> <u>Wash Water</u> <u>Needing</u> <u>Treatment</u>
Theoretical Results				
1	43.6	0.76	95.4	13.3
10	138	0.23	86.0	4.1
100	436	0.061	59.3	1.1
Experimental Results for Plant 3630				
4	200	0.10	69	1.8

*CR - Silver concentration of prewash overflow after silver recovery.

**CT - Silver concentration in prewash tank.

Plant 6174 installed an experimental prewash system on the paper processors and measured the silver concentration in the trench containing the rinse wastewater. The silver concentration of the rinse wastewater before and after installation of the prewash system averaged 2.8 mg/liter and 0.52 mg/liter, respectively.

Experimentation has shown that there are a number of potential problems in using the prewash system. These problems may be caused by trace chemical build-up, increased fix time, and improper washing. One investigator found an increase in yellow stain six months after processing and had problems with biological growth. Plants 3630 and 6174 experienced difficulties in controlling the silver recovery system on the prewash overflow and had physical quality problems introduced by required additional squeegees.

Recently a photographic supplies manufacturer, after extensive evaluation, has approved the use of a low-flow prewash on the EP-2 NR process as an alternative to the conventional wash system. The application of a prewash

system includes a recommendation for electrolytic silver recovery on the combined waste bleach-fix and prewash overflow and metallic replacement silver recovery on the electrolytic unit effluent combined with the final wash water. Suggestions for controlling biological growth in the prewash water holding tank and prewash tank are included. The recommendations include cleaning the prewash tanks with a 5 to 12 percent sodium hypochlorite solution at least weekly or more often depending upon the processing conditions.

Wash Water Recycle

Wastewater hydraulic loads can be reduced significantly by using countercurrent washing and partial recycle of wash water. The countercurrent washing referred to here involves the use of segmented wash tanks after specific chemical tanks such as bleach-fix. It does not refer to the practice of pumping the same wash water from one wash tank after a chemical tank to another wash tank after a different chemical processing solution. This could result in the intermixing of chemical solutions in the improper sequence with the process chemistry. Table VII-11 shows the results of countercurrent washing and wash water recycle for two plants. Both plants are large and a major proportion of the total production is prints made from original negatives (6208 is a movie lab and 7781 is a portrait studio). The recycled water is used only for the print processes at 6208 and is used for the print process and the final wash on the negative process at 7781.

The magnitude of the effluent hydraulic load from a photoprocessing plant is mostly determined by how the plant handles its process wash water, which is by far the largest use of water in this industry. The use of countercurrent washing and partial recycle of wash water after treatment with reverse osmosis reduces effluent hydraulic loads by over 90 percent. However, the applicability of these water-saving techniques depends on the processes used and the process and product mix at a particular plant. As discussed in Section III, potential problems such as biological growth, trace chemical build-up, and insufficient washing must be controlled to prevent short- and long-term adverse effects on product quality.

TABLE VII-11
Effect of Countercurrent Washing and Wash Water
Recycle on Effluent Hydraulic Loads

<u>Plant</u>	<u>Effluent Hydraulic Load, l/1,000 sq m (gal/1,000 sq ft)</u>	<u>Counter-current Washing Used</u>	<u>Recycle of Wash Water</u>
6208	98,000 (2,400) ¹	no	30% ²
7781	5,010 (123) ¹	yes	60% ³

¹ Average of 3 24-hour composite samples

² After ion exchange treatment

³ After reverse osmosis treatment

END-OF-PIPE TREATMENT TECHNOLOGIES

The end-of-pipe treatment technologies employed by photoprocessing plants were discussed in Section III and include precipitation, settling, ozonation, filtration, clarification, aeration, neutralization, equalization, chlorination, flocculation, and reverse osmosis. Ten of the twenty plants visited by EPA employed one or more of these treatment technologies as follows:

<u>Plant No.</u>	<u>Technologies Employed</u>
1465	ozonation (concentrated streams only)
4229	equalization, settling
3455	equalization, flocculation, precipitation, clarification, chlorination, settling, filtration
9297	equalization, aeration, ozonation, settling
2714	equalization, neutralization, reverse osmosis (wash water only)
4550	precipitation, flocculation, settling (only waste fix containing iron-cyanide complexes)
4849	chlorination (wash water only)
7781	aeration, ozonation, precipitation, settling, filtration
3075	settling
2387	settling

The effluent compositions obtained by several plants as a result of the treatments used were shown in Section V. The two facilities having the most extensive treatment systems (plants 7781 and 2714) also report the lowest effluent loadings for BOD, TDS, and other parameters. Also, the facilities having no end-of-pipe treatments (plants 2465, 4666, 5552, 4228 and 3437) report high effluent loadings of cyanides, BOD, and TDS. For some parameters, the loadings from these "no treatment" sites are as much as an order of magnitude greater than those reported for plants 7781 and 2714. Further inspection of the data shows considerable variation for a number of parameters even among plants having no end-of-pipe treatment. The reasons for these variations lie in differences in specific products processed, in water usage, and in plant operating procedures. These factors can influence the amounts of discharged materials. However, despite the variations in

waste loadings observed among plants, it is also observed that the application of end-of-pipe treatments does generally lead to reduced discharges of several pollutants.

Cadmium and chromium do not occur in all photoprocessing waste streams, and no generally applicable treatment technology was observed being used for these specific pollutants. Cadmium occurs in the color developer and bleach-fix wastes of plants using certain papers. The major manufacturer of papers of this type has indicated their intention to phase out cadmium. Chromium occurs in the processing waste streams from one color motion picture film process and some black and white reversal processes.

Plant 7781 has used ion exchange to remove cadmium from their wastewaters. The column was eluted and a concentrated cadmium solution resulted which had to be treated or disposed of by contractor hauling.

Plants using dichromate bleach can reduce the amount of chromium in their effluent by treating the plant effluent or by segregating and treating the after-bleach wash water and dichromate bleach solution wastes. The wash water and waste bleach contain a mixture of hexavalent and trivalent chromium. A waste bleach sample from plant 6208 had a hexavalent chromium concentration of 1,020 mg/liter and a total chromium concentration of 1,700 mg/liter. The plant effluent had hexavalent chromium and total chromium concentration ranges of <0.02 to 0.44 mg/liter and 2.8 to 3.5 mg/liter, respectively, indicating that most of the hexavalent chromium was reduced to the trivalent form in the mixed waste effluent.

Treatment of the total effluent to reduce the amount of chromium would consist of pH adjustment for precipitation of the trivalent chromium and clarification. Subsequent filtration would reduce the chromium to lower levels. The filter cake containing the precipitated chromium salts would be disposed of by contractor hauling for landfilling or equivalent disposal method.

An alternative method would be to mix the segregated after-bleach wash and bleach solution wastes and treat the relatively low volume mixture. The treatment would consist of hexavalent chromium reduction, pH adjustment for

precipitation and diatomaceous earth filtration. This technology has been successfully demonstrated by the electroplating industry for treatment of chromium. Chromium reduction efficiencies of 95 percent were achieved in waste streams having up to 525 mg/liter chromium. After-bleach wash water contains up to 100 mg/liter chromium and the waste bleach approximately 1,700 mg/liter. The mixed waste solution would have a chromium concentration of about 115 mg/liter based on the relative flows of 20 liters/hr and 2,300 liters/hr of waste bleach and wash water, respectively. Thus, the photographic wastes are within the chromium concentration range successfully treated in the electroplating industry.

Plant 6208 has, on an experimental basis, demonstrated that further volume reduction of wastewater containing chromium can be achieved by treating the wash water with an ion-exchange resin. Chromium was concentrated in the relatively low volume elutriant from the column and the wash water was recycled. The elutriant could be treated using the technology described above. The demonstration unit at 6208 removed chromium from the wash water with an average efficiency of 92 percent during normal operation.

During the later part of this study, plant 7781 completed the installation of a system which reduces the discharge of process wastewater to a minimum. (All hydraulic load and in-plant and effluent data reported in Sections V and VII for 7781 result from the in-process control and treatment system which was in place prior to the modified system that is described below. The characteristics of the before-modification system were also described in Sections V and VII.) The system, shown schematically in Figure VII-9, consists of conventional and advanced in-process controls to reduce the production of wastewater and three stages of wastewater evaporation. In-process controls used on the film process include prebath recycle, EDTA bleach regeneration, and continuous silver recovery from the fix solution. The paper process controls are: developer regeneration by ion exchange and chemical addition, bleach-fix regeneration after electrolytic silver recovery, 50 percent stabilizer recycle by chemical addition, and countercurrent after-fix washing to reduce wash water volume. All film wash water, except the after-prebath wash, and the paper wash water are collected and treated with two

reverse osmosis units. The permeate is recycled to the process. The concentrate is combined with the waste film developer, stop, and all other waste solutions and directed to the two-stage evaporator. At this point the waste contains about 2 percent solids. The first stage of the evaporator increases the solids concentration to about 20 percent and the second stage to about 65 percent. This wastewater is then pumped to the film wipe evaporator which increases the solids content of the waste to about 80 percent. The solid waste is sent to a smelter for silver reclamation. The condensate from both evaporators is condensed and passed through an ion exchange unit for reduction of ammonia. The condensed water is recycled to the process and the elutriant containing ammonia is used as lawn fertilizer or disposed of by contractor hauling. The plant has experienced mechanical difficulties with the wipe-film evaporator which require periodic repair maintenance. During these repair periods, the evaporator is shut down and the 65 percent solids content wastewater from the two-stage evaporator is contractor hauled.

VARIABILITY FACTOR

Even plants which are achieving state-of-the-art pollutant reduction occasionally experience days of above average pollutant discharge. These high days may reflect temporary imbalances in the treatment system caused by fluctuations in flow, in raw waste loading, in chemical feed, or in mixing flows within the tanks. Allowance for the random variability of the discharge of a well designed and operated plant may be made by applying a "variability factor" to the expected long-term average. The expected long-term average is then multiplied by the variability factor.

The formulation of appropriate variability factors given below is based upon observed discharge data from operating plants. The daily maximum and the 30-day average maximum variability factors, at the 99 percent confidence level, were calculated using the following relationships:

Daily maximum variability factor = $e \exp [2.326 SY - 0.5 (SY)^2]$
Where SY = standard deviation of the natural logarithms of
the measured concentrations

30-day average maximum = $[\text{mean } X + 2.326 \text{ SX}/\text{sq rt } 30]/\text{mean } X$

Where X = measured concentration

SX = standard deviation of the measured concentrations

The results of this analysis on the available long-term data are shown in Table VII-12. These data supplied by plants 6208 and 7781 are concentration values obtained from daily samples of effluent over various time periods. The raw data are given in Appendix B. A cumulative distribution plot of the silver data from plant 6208 is shown in Figure VII-10.

TABLE VII-12
POLLUTANT VARIABILITY FACTORS

Parameter	Plant	Control	Number of Values	Mean, mg/liter		Standard Deviation		30-day Average Maximum Variability Factor	Single Day Maximum Variability Factor
				X	Y	SX	SY		
Silver	6208	Ion Exchange	57	0.46	-1.1	0.37	0.96	1.3	5.9
	7781	Ion Exchange	42	6.2	1.7	3.4	0.57	1.2	3.2
	7781	Precipitation	20	4.0	1.2	2.5	0.64	1.3	3.6
				Silver Average		1.3		1.3	4.2
Total Cyanide	6208	Regeneration	56	0.12	-4.0	0.36	1.7	2.2	12
Chromium	6208	None	57	3.4	1.0	1.9	0.82	1.2	4.8
	7781	Ion Exchange	64	1.2	-0.16	0.91	0.81	1.3	4.7
	7781	Precipitation	20	0.12	-2.4	0.069	0.72	1.2	4.1
				Cadmium Average		1.3		1.3	4.4
Total Cyanide	Table VII-4	Regeneration, Precipitation	14	5.1	1.5	2.5	0.66	1.2	3.7

$$\text{Mean } X = \frac{X_1 + X_2 + \dots + X_n}{n}$$

$$\text{Mean } Y = \frac{Y_1 + Y_2 + \dots + Y_n}{n}$$

X = measured value, mg/liter

Where $Y_1 = \ln X_1$

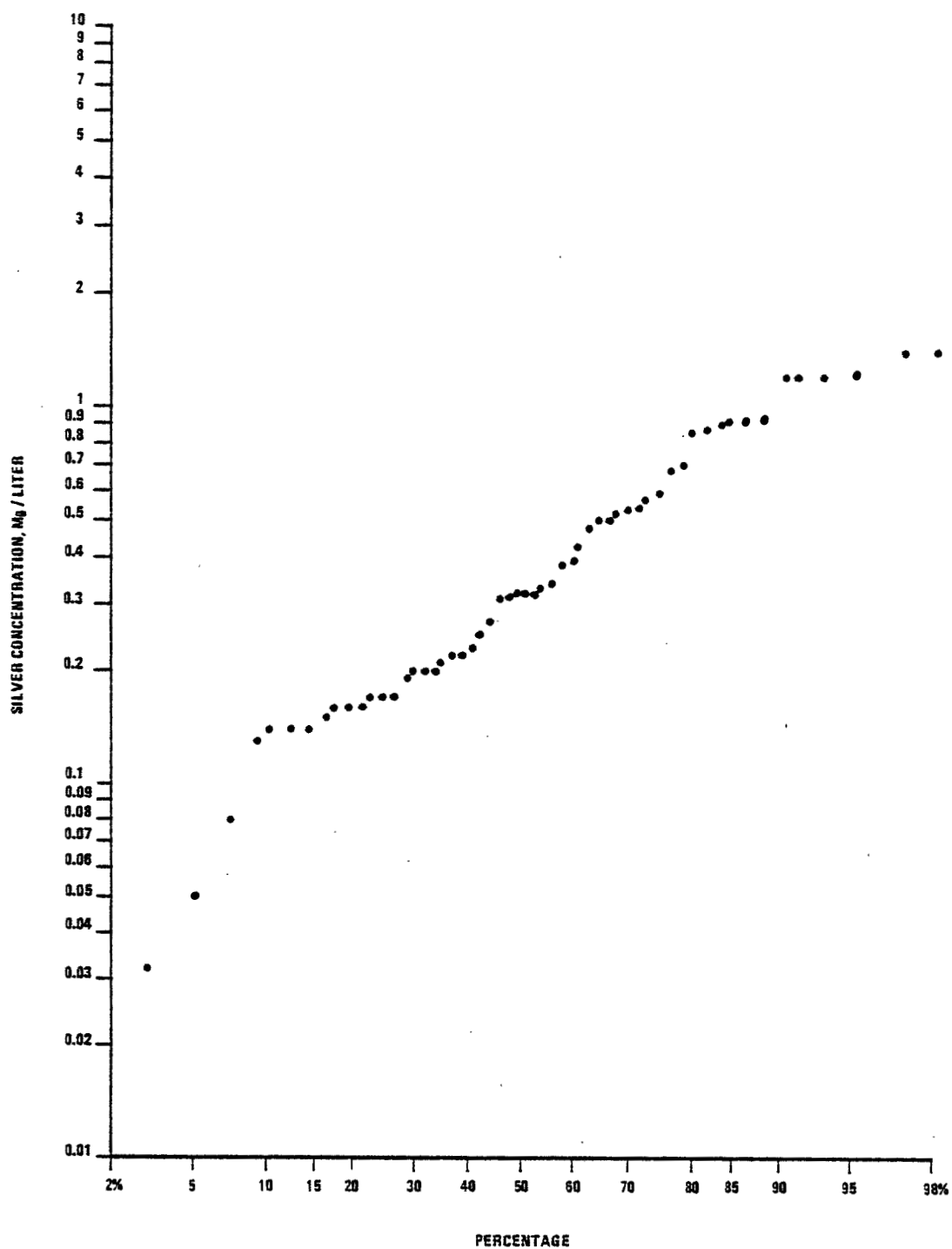


FIGURE VII-10. LONG-TERM SILVER CONCENTRATION IN EFFLUENT AT PLANT 6208

SECTION VIII

COST, ENERGY, WASTE REDUCTION BENEFITS AND NON-WATER ASPECTS OF TREATMENT AND CONTROL TECHNOLOGIES

INTRODUCTION

Costs for the treatment and control of waterborne pollutants in the photoprocessing industry have been developed for various levels of technology currently in use in the industry. These technologies were described in Section III and their effectiveness was discussed in Section VII.

In developing the costs for the various levels of technologies, factors such as plant age, space requirements, and geographic location were considered. Age may indirectly influence control and treatment costs through the effects of isolation and control of wastes and space limitations. It was found that age was not a major cost contributing factor in this industry. The control and isolation of wastes are not generally a problem regardless of plant age because, by the nature of the photographic processing equipment and operation, wastes can be isolated. It is also observed that space limitations are not generally a problem because the control equipment is relatively compact and self-contained.

Geographic location does not significantly affect the costs of control and treatment technologies in this industry because processes used are the same throughout the United States, irrespective of geography or climate.

GENERAL COST REFERENCES AND RATIONALE

Cost information contained in this report was obtained from industry, engineering firms, equipment suppliers, and published literature. Whenever possible, costs were taken from actual installations, engineering estimates for projected facilities as supplied by contributing companies, or from equipment suppliers' quoted prices. In the absence of such information, cost estimates were developed from actual costs incurred in other industries for treatment of similar wastes. Such cost estimates were developed for the treatment of dichromate bleach wastes by using cost

information from the electroplating point source category for the treatment of chromium-containing wastes.

Interest Costs and Equity Financing Charges

Estimates for this study were based on 15 percent cost of capital, representing an overall average for either interest paid or return on investment required.

Time Basis for Costs

All cost estimates are based on 1977 prices and when necessary have been adjusted to this basis using the Chemical Engineering facility cost index.

Useful Service Life

The useful service life of treatment and control equipment varies depending on the nature of the equipment and process involved, its use pattern, maintenance and numerous other factors. Individual companies may apply service lives based on their actual experience for internal amortization. Internal Revenue Service provides guidelines for tax purposes which are intended to approximate average experience. Based on industry practice and condensed IRS guideline information, a 10-year useful service life value for control and treatment equipment was used.

Depreciation

The economic value of treatment and control equipment and facilities decreases over its service life. At the end of the useful life, it is usually assumed that the salvage or recovery value becomes zero. For IRS tax purposes or internal depreciation provisions, straight line, or accelerated write-off schedules may be used. Straight line depreciation was used solely in this report.

Capital Investment

Capital investment is defined as all front-end, out-of-pocket expenditures for providing treatment or control facilities. These costs include costs for research and development necessary to establish the process, equipment, construction and installation, services,

engineering, special start-up costs and contractor profits and contingencies.

Annual Capital Costs

Most, if not all, of the capital costs are accrued during the procurement and installation of the equipment. This present worth sum can be converted to equivalent uniform annual disbursements by utilizing the Capital Recovery Factor Method:

$$\text{Uniform Annual Disbursement} = \frac{P i (1 + i)^{\text{nth power}}}{[(1 + i)^{\text{nth power}}] - 1}$$

Where P = present value (capital expenditures),

i = interest rate, %/100

n = useful life in years

Using an interest cost of 15 percent and a useful life of 10 years:

$$\begin{aligned}\text{Uniform Annual Disbursement} &= \frac{0.15 P (1.15)^{10}}{[(1.15)^{10}] - 1} \\ &= 0.199 P\end{aligned}$$

Land Costs

Land costs are not a significant factor affecting control and treatment costs in this industry, since the equipment is generally compact and self-contained and can be housed in existing facilities. Interior space costs were not considered.

Operating Expenses

Annual costs of operating the treatment or control facilities include labor, supervision, materials, maintenance, taxes, and insurance. Power and energy costs were estimated by determining the electrical requirements for the equipment and using five cents per kilowatt-hour for the cost of electrical energy. Operating costs combined with annualized capital costs give the total annual costs

for treatment and control. The total annual operating costs minus the return from recovered silver and chemical cost savings represent the net annual operating costs. No interest cost was included for operating (working) capital. Since working capital might be assumed to be one-sixth to one-third of annual operating costs (excluding depreciation), about 1-2 percent of total operating costs might be involved. This is considered to be well within the accuracy of the estimates.

It is recognized that all costs and cost benefits for conventional silver recovery and bleach regeneration are costs incurred as a result of normal industry business practice based on economic rather than environmental incentives. As was shown in Table VII-1, most of the industry use these in-process controls. Costs for these controls are included in this section for information purposes and for those few facilities that do not presently use them.

Representative Facilities

Some cost information was obtained from the plants studied and from control and treatment equipment suppliers. These cost data cover a wide range of plant sizes in terms of production. To facilitate costing, "typical" plant sizes were selected as being representative of each of four plant size categories that cover the range of available cost data. The "typical" plant production and production range for each representative category are given in Table VIII-1. Costs are developed for the "typical" plant in each category in the following subsections.

CONTROL AND TREATMENT COSTS FOR REPRESENTATIVE PHOTOPROCESSING PLANTS

Control and treatment costs were developed for various levels of technology at representative photographic processing plants. These costs were developed from actual cost information supplied by the plants studied and from cost estimates provided by control and treatment equipment suppliers. The costed control technologies are: (1) various levels of silver recovery, (2) EDTA bleach regeneration, (3) ferricyanide bleach regeneration, (4) precipitation of waste fix for ferricyanide reduction, (5) treatment of dichromate

TABLE VIII-1
PRODUCTION CATEGORIES

Production Size Category	Daily Production		Yearly* Production	
	Range 1,000 sq m/day (1,000 sq ft/day)	Typical 1,000 sq m/day (1,000 sq ft/day)	Range 1,000 sq m/yr (1,000 sq ft/yr)	Typical 1,000 sq m/yr (1,000 sq ft/yr)
A	0.093 - 0.19 (1.0 - 2.0)	0.14 (1.5)	23 - 46 (250 - 500)	35 (375)
B	0.19 - 0.46 (2.0 - 5.0)	0.33 (3.5)	46 - 116 (500 - 1,250)	81 (875)
C	0.46 - 4.6 (5.0 - 50)	1.4 (15)	116 - 1,160 (1,250 - 12,500)	350 (3,750)
D	4.6 - ∞ (50 - ∞)	7.0 (75)	1,160 - ∞ (12,500 - ∞)	1,740 (18,750)

* 250 production days per year

bleach waste for chromium reduction, and (6) use of conventional and advanced in-process controls and multi-stage evaporation to reduce process wastewater discharge to a minimum. Each of the technologies has been costed separately. To determine the total costs for a particular plant, the costs for the individual technologies should be summed depending on the size of the plant and particular system used.

The best fit regression line shown on all graphs in this section was determined by regression analysis. This analysis involved calculating the linear, exponential, logarithmic, and power regression lines and the coefficient of determination (r^2) which is a measure of goodness of fit. The regression fit which had the most favorable coefficient of determination was selected for use in cost determinations.

Silver Recovery

Silver recovery costs were developed for the recovery of silver from fix solutions using conventional recovery methods and for the recovery of silver from after-fix wash water using ion exchange or reverse osmosis. These costs, as determined for the various typical plant sizes, are given in Tables VIII-2 through VIII-4.

Specific Costing References and Rationale for Silver Recovery

Silver Recovery from Fix Solutions Using Conventional Methods--

Figure VIII-1 is a graph of silver recovery capital investment costs versus production which includes plant supplied actual costs and the estimated range of costs supplied by a major equipment supplier for representative plant sizes B, C, and D. All costs include installation. The cost information supplied by the individual plants includes costs for all types of conventional silver recovery equipment. The cost data supplied by the equipment supplier were based on the following assumptions for the B, C, and D representative plants:

TABLE VIII-2
COSTS FOR RECOVERY OF SILVER FROM FIX SOLUTIONS
USING CONVENTIONAL METHODS

Plant Size	A	B	C	D
Typical Annual Production, 1,000 sq m/year (1,000 sq ft/year)	35 (375)	81 (875)	350 (3,750)	1,740 (18,750)
1977 Dollars				
Capital Investment Required	4,500	8,600	26,400	90,700
Annual Costs:				
Capital Recovery	900	1,700	5,300	18,000
Operating and Maintenance	340	800	3,400	16,800
Energy and Power	500	500	1,200	2,300
Total	1,740	3,000	9,900	37,100
Annual Resource Recovery	19,100	44,600	191,000	956,000
Net Annual Cost (Benefit)	(17,360)	(41,600)	(181,100)	(918,900)

TABLE VIII-3
COSTS FOR RECOVERY OF SILVER FROM AFTER-FIX
WASH WATERS BY ION EXCHANGE

Plant Size	A	B	C	D
Typical Annual Production, 1,000 sq m/year (1,000 sq ft/year)	35 (375)	81 (875)	350 (3,750)	1,740 (18,750)
1977 Dollars				
Capital Investment Required	10,800	10,800	31,200	90,700
Annual Costs:				
Capital Recovery	2,150	2,150	6,200	18,000
Operating and Maintenance	1,900	3,130	10,100	46,100
Energy and Power	30	70	300	1,500
Total	4,080	5,350	16,600	65,600
Annual Resource Recovery	2,600	6,100	26,000	130,000
Net Annual Cost (Benefit)	1,480	(750)	(9,400)	(64,400)

TABLE VIII-4
COSTS FOR RECOVERY OF SILVER FROM AFTER-FIX
WASH WATERS BY REVERSE OSMOSIS AND PRECIPITATION

Plant Size	A	B	C	D
Typical Annual Production, 1,000 sq m/year (1,000 sq ft/year)	35 (375)	81 (875)	350 (3,750)	1,740 (18,750)
1977 Dollars				
Capital Investment Required	15,300	19,400	34,800	85,800
Annual Costs:				
Capital Recovery	3,000	3,900	6,900	17,100
Operating and Maintenance	5,150	6,600	16,400	61,000
Energy and Power	800	800	1,900	2,300
Total	8,950	11,300	25,200	80,400
Annual Resource Recovery	2,600	6,100	26,000	130,000
Net Annual Cost (Benefit)	6,350	5,200	(800)	(49,600)

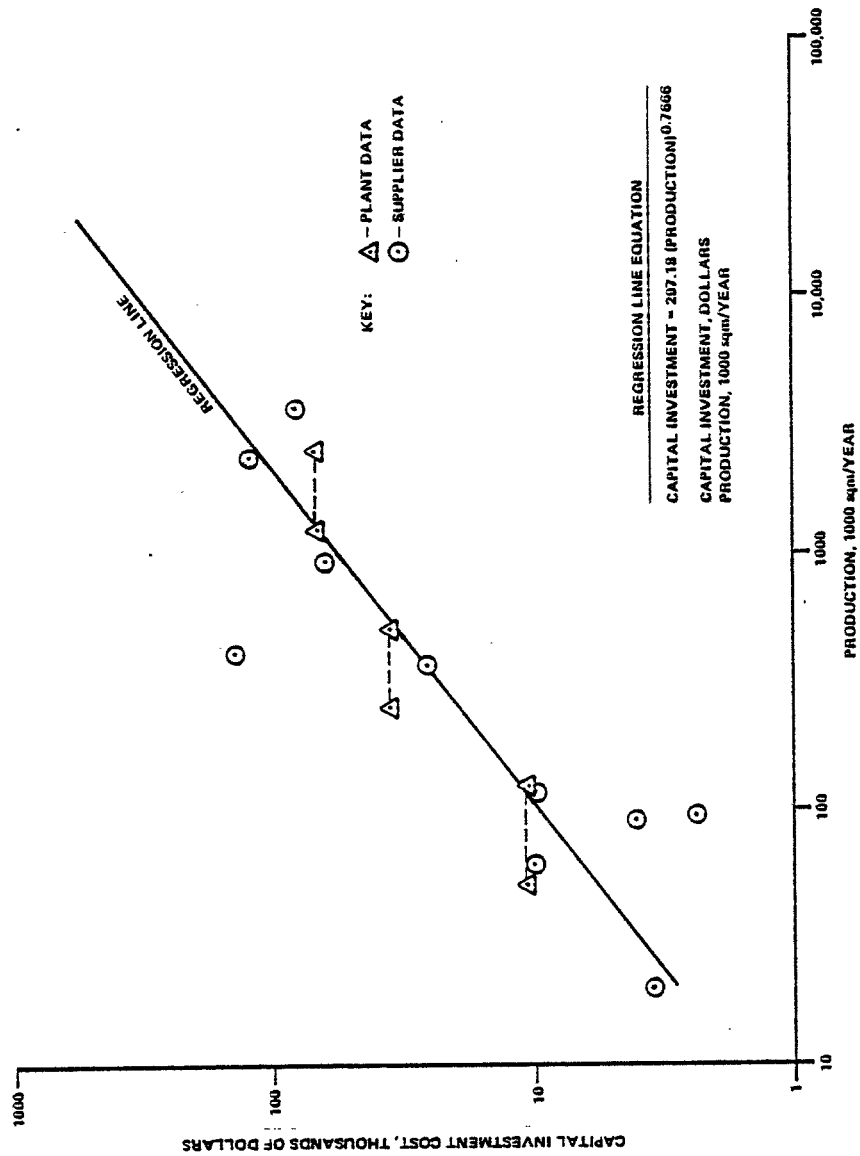


FIGURE VIII-1 SILVER RECOVERY CAPITAL INVESTMENT COSTS VS PRODUCTION

- (1) Color negative film and paper are processed with a balance of 10 percent film and 90 percent paper.
- (2) A recirculating electrolytic silver recovery system is used on the film fix with electrolytic "tailing" on fix overflow.
- (3) A batch electrolytic silver recovery system is used on the paper bleach-fix.
- (4) The B plant uses electrolytic tailing only on film fix overflow, i.e., no recirculating system.
- (5) Assumes the B and C plants have two continuous film processors and the D plant has three continuous film processors.
- (6) Installation costs are included.

The regression analysis of the data presented in Figure VIII-1 yielded the following relationship between capital investment for silver recovery equipment and production.

$$CI = 297.18(P) \exp. 0.7666$$

where:

CI = Capital investment, dollars
P = Production, 1,000 sq m/yr

This relationship was used to calculate the capital investment costs given in Table VIII-2.

Figure VIII-2 is a graph of silver recovery operating costs versus production. This curve was derived from plant supplied actual costs. The regression line is represented by the following equation:

$$OC = 9.8119(P) \exp. 0.9981$$

where:

OC = Operating cost, dollars
P = Production, 1,000 sq m/yr

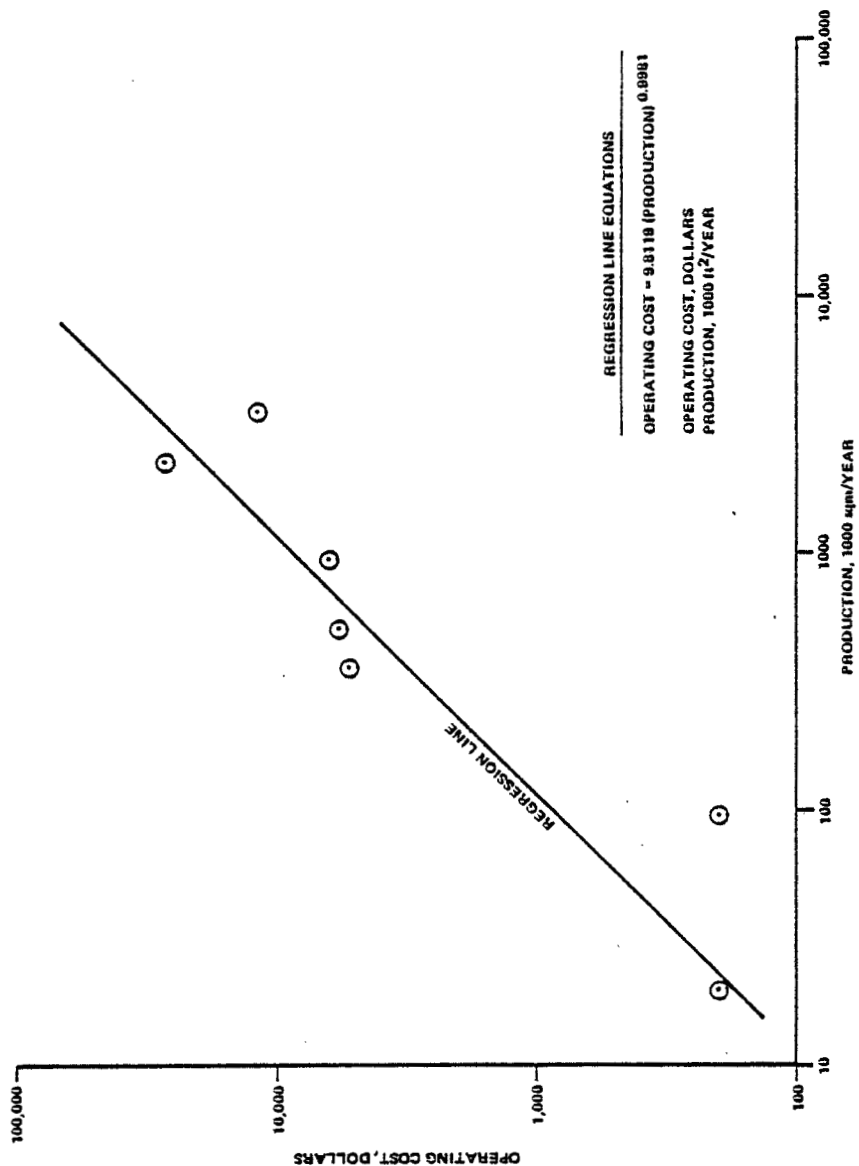


FIGURE VIII-2 SILVER RECOVERY OPERATING COSTS VS PRODUCTION

Handwritten signature/initials

This relationship was used to calculate the operating costs in Table VIII-2.

Energy and power estimates for the representative plants were estimated from power requirements provided by the equipment supplier, an electrical energy cost of \$0.05 per kilowatt hour, and an assumed 20 hours per day, 250 days per year operation.

The annual resource recovery cost is a benefit cost that was derived from the amount of silver contained in the emulsion of the material processed by the representative plants and a silver value of \$12.00 per troy ounce. The silver recovery benefit calculation is based on the following:

- (1) A color negative plant having a 10:90 film to paper ratio.
- (2) Ninety percent of the total silver in the emulsion is contained in the fix and ten percent of the total silver is carried into the after-fix wash water.
- (3) The conventional silver recovery methods yield ninety percent of the silver contained in the fix, i.e., 81 percent of the total silver contained in the processed film and paper.

Silver Recovery from After-Fix Wash Water Using Ion Exchange--

The costs for the recovery of silver from after-fix wash water by ion exchange are given in Table VIII-3. These costs were developed using the following bases:

- (1) Information on capital and operating costs was supplied by ion exchange equipment suppliers.
- (2) The amount of equipment for each plant size is based on an estimate of the after-fix wash water flow. This estimate is based on the assumption that the after-fix wash water flow is 50 percent of the total process water hydraulic load. The average total process water hydraulic load determined for the industry is 157,000 liters/1,000 sq m (3,850 gal/1,000 sq ft) based on the data for

70 plants given in Table V-4. Therefore, the estimated after-fix wash water load is 78,500 liters/1,000 sq m (1,930 gal/1,000 sq ft).

Based on this flow estimate, the numbers of ion exchange tanks required by the various plant sizes are:

<u>Plant Size</u>	<u>Pairs of Ion Exchange Tanks</u>
A	1
B	1
C	2
D	7

- (3) Daily hours of operation for the representative plants were assumed to be 8, 8, 16, and 24 for the A, B, C, and D plants, respectively.
- (4) The maximum flow rate to each pair of ion exchange tanks is 57 liters/min (15 gal/min).
- (5) The installation costs (part of the capital investment), which include the necessary plumbing and electrical work in preparation for delivery of equipment, are estimated to be \$500 per pair of ion exchange tanks. Also included as installation costs are ten treated water analyses at \$30 each. These analyses are performed during start-up.
- (6) The ion exchange tanks are regenerated off site by the equipment supplier. The fee charged for this service is part of the operating cost. The in-plant operating and maintenance costs include maintenance labor of one hour per week per pair of tanks (labor rate at \$15,000 per year) plus one treated water analysis per regeneration at \$30 each.
- (7) The annual resource recovery cost benefit is based on the silver recovered from the after-fix wash water and waste fix. (It is assumed that the waste fix, after conventional silver recovery, is mixed with the after-fix wash water.) A total of 19 percent of the silver contained in the emulsion is

available to the ion exchange system (10 percent in the wash water plus nine percent remaining in the waste fix after conventional silver recovery). With an assumed ion exchange efficiency of 80 percent and a silver refining fee of 25 percent, the silver returned to the plant amounts to 11 percent of the silver contained in the emulsion. The annual resource recovery was computed for a 10:90 color negative film to paper ratio and with a silver value of \$12 per troy ounce.

Silver Recovery from After-Fix Wash Water Using Reverse Osmosis and Precipitation--

The costs for the recovery of silver from after-fix wash water by reverse osmosis and precipitation are given in Table VIII-4. Plant 7781 used, and supplied cost information for, a precipitation process to recover the silver from the reverse osmosis concentrate. It may be possible to use other methods to recover silver from the reverse osmosis concentrate, but no cost information was available for this specific application. Costs for the reverse osmosis and precipitation processes were developed using the following bases:

- (1) The reverse osmosis capital investment costs versus flow were provided by an equipment supplier and are shown in Figure VIII-3. The capital investment costs for the reverse osmosis equipment were derived from the following relationship:

$$CI = 9556 + 0.4016 F$$

where:

CI = Capital investment, dollars
F - Flow, 1,000 liters per day

The production of the representative plants was related to the flow by linear scaling of the input flow to a reverse osmosis unit used by plant 7781.

- (2) Reverse osmosis operating and maintenance and power costs are based on information from an equipment

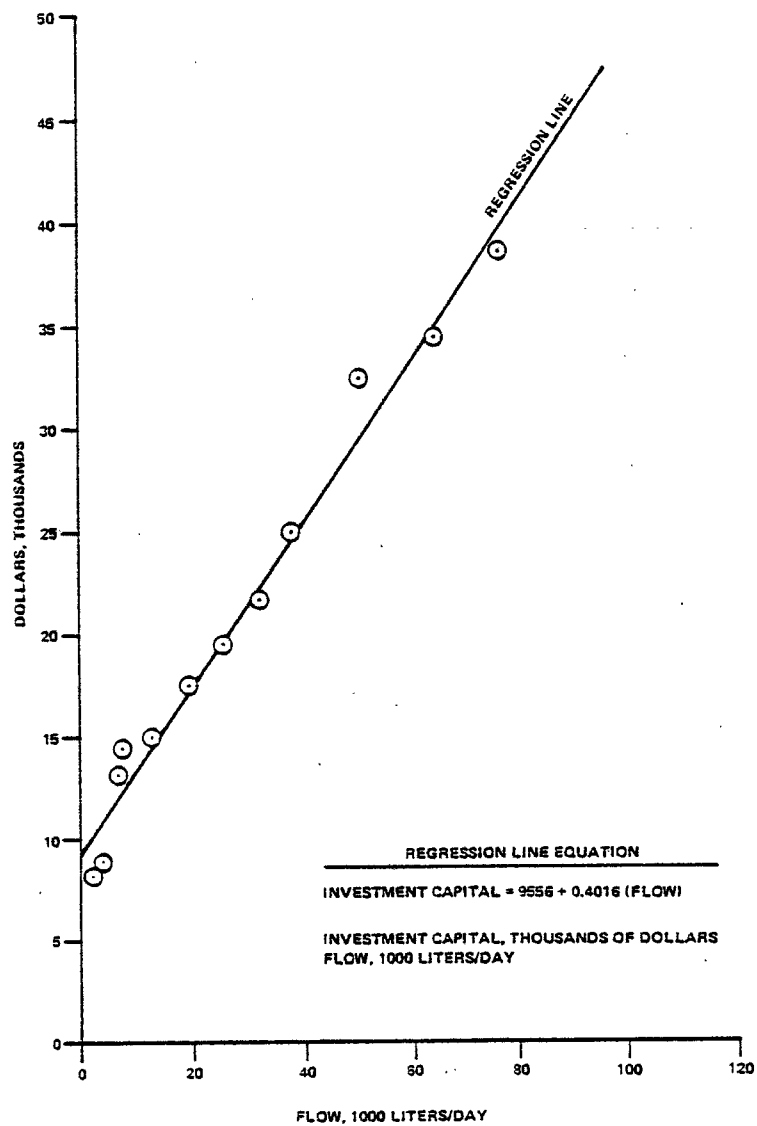


FIGURE VIII-3 REVERSE OSMOSIS EQUIPMENT CAPITAL INVESTMENT COST VS FLOW
INCLUDES REVERSE OSMOSIS, CONDUCTIVITY CONTROL AND PREFILTER

supplier. These operating and maintenance costs include membrane replacement and cleaning solution costs and labor costs for maintenance and solution analyses.

- (3) The capital investment for the precipitation of silver from the concentrate was obtained using cost information for plant 7781 and the following relationship:

$$CN = C r \exp 0.6$$

where:

CN = capital investment for representative plants, dollars
 C = capital investment incurred by plant 7781, dollars
 r = production ratio of representative plant to plant 7781.

- (4) Precipitation operating and maintenance and power costs were directly scaled to plant 7781.
- (5) The annual resource recovery cost benefit, as in ion exchange, is based on the silver recovered from the after-fix wash water combined with the waste fix (after conventional silver recovery). The amount of silver recovered is estimated to be the same as that determined for ion exchange.

EDTA Bleach Regeneration

The costed EDTA regeneration process consists of aeration with chemical addition. If bleach-fix is the regenerated material, it is assumed that the silver in the spent bleach-fix has been recovered by the techniques discussed in the previous section.

The collected information used to determine costs is graphically summarized in Figures VIII-4 and VIII-5. The costs, as determined for the representative plants, are shown in Table VIII-5.

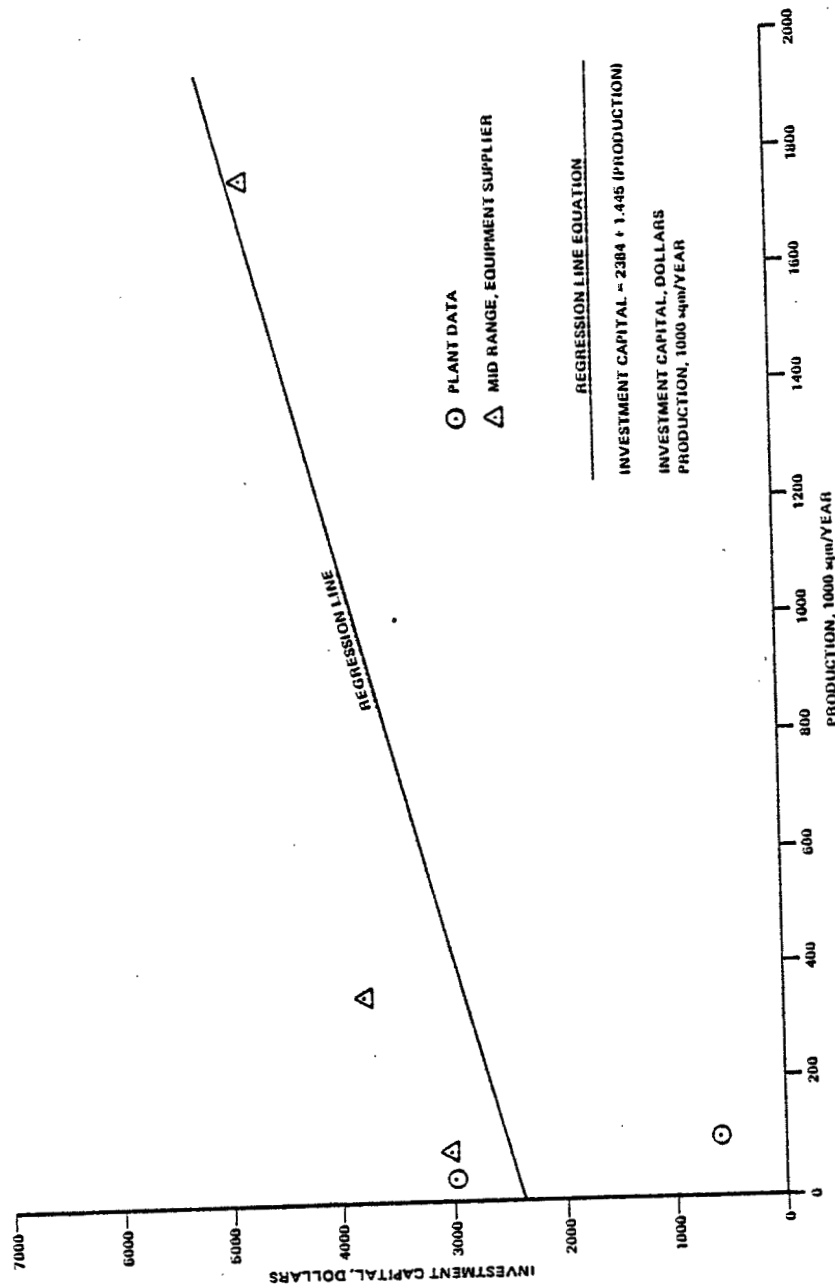


FIGURE VIII-4 F_2 EDTA BLEACH REGENERATION INVESTED CAPITAL COSTS VS PRODUCTION

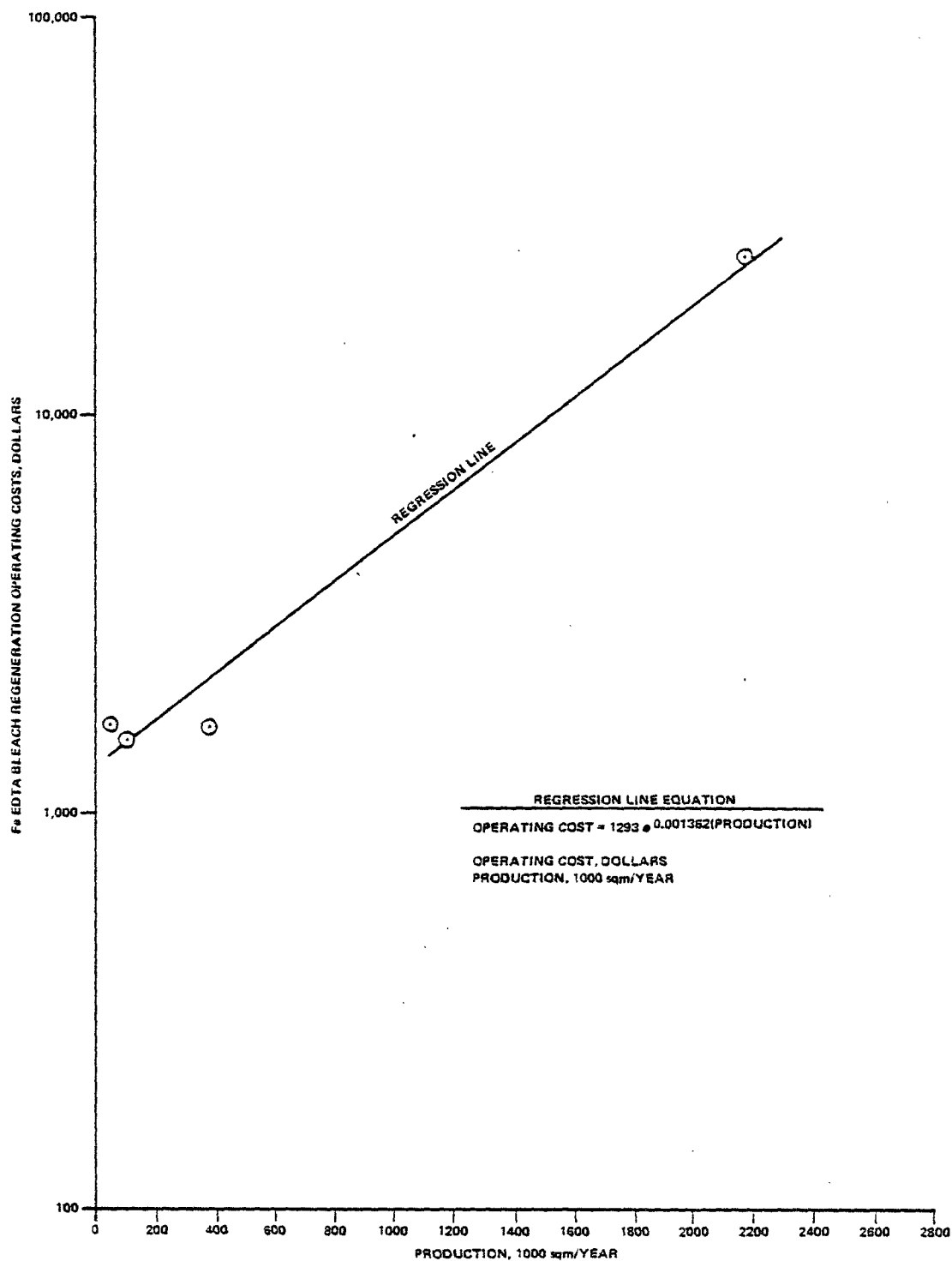


FIGURE VIII-5 Fe EDTA BLEACH REGENERATION OPERATING COSTS VS PRODUCTION

VIII-19
238

TABLE VIII-5
COSTS FOR FERRIC EDTA BLEACH REGENERATION BY AERATION
AND CHEMICAL ADDITION

Plant Size	A	B	C	D
Typical Annual Production, 1,000 sq m/year (1,000 sq ft/year)	35 (375)	81 (875)	350 (3,750)	1,740 (18,750)
1977 Dollars				
Capital Investment Required	2,400	2,500	2,900	4,900
Annual Costs:				
Capital Recovery	480	500	600	1,000
Operating and Maintenance	1,360	1,400	2,100	13,800
Energy and Power	200	200	600	1,000
Total	2,040	2,100	3,300	15,800
Annual Resource Recovery	9,200	21,000	93,300	465,000
Net Annual Cost (Benefit)	(7,160)	(18,900)	(90,000)	(449,200)

Specific Costing References and Rationale for EDTA Bleach Regeneration

Figure VIII-4 is a graph of EDTA bleach regeneration capital investment costs versus production which represents plant supplied actual costs and the estimated costs supplied by a control equipment supplier for the representative plants. The costs include installation. The cost data supplied by the equipment supplier were based on the following assumptions for the representative plants:

- (1) Color negative film and paper are processed with a balance of 10 percent film and 90 percent paper.
- (2) The film process uses EDTA bleach and the paper process uses bleach-fix with a ferric EDTA base.

The following relationship between capital investment and production was derived by a regression analysis of the data presented in Figure VIII-4:

$$CI = 2384 + 1.445 P$$

where:

CI = Capital investment, dollars
P = Production, 1,000 sq m/yr

This relationship was used to calculate the capital investment costs presented in Table VIII-5.

Figure VIII-5 is a graph of EDTA bleach regeneration operating costs versus production which represents plant supplied actual costs. The following relationship between operating costs and production was derived:

$$OC = 1293 e \exp. 0.001362P$$

where:

OC = Operating cost, dollars
P = Production, 1,000 sq m/yr

The energy and power requirements were assumed to be for 1, 1, 3, and 5 horsepower motors, for the A, B, C, and D

plants, respectively, to operate air compressors for aeration. Electric energy costs were assumed to be \$0.05 per kilowatt hour with an operation time of 20 hours per day, 250 days per year.

Annual resource recovery benefits are based on the chemical savings gained by not disposing of the bleach. The determination was made, for each plant size, by taking 80 percent of the bleach chemical costs and subtracting the cost of the bleach regenerate chemicals. The following assumptions were made:

- (1) Eighty percent of the waste bleach is regenerated.
- (2) To determine bleach and bleach regenerate costs, price information for the C-41 color film and for the EP-2 color paper processes was used.
- (3) Replenishment rates of 0.925 liters/sq m (0.0227 gal/sq ft) and 0.322 liters/sq m (0.0079 gal/sq ft) were used for the C-41 bleach and the EP-2 bleach-fix, respectively.

Ferricyanide Bleach Regeneration

The costed ferricyanide bleach regeneration process utilizes ozonation for regeneration. The costs, as determined for the representative plants, are shown in Table VIII-6.

Specific Costing References and Rationale for Ferricyanide Bleach Regeneration

The specific capital investment cost information was supplied by a control equipment supplier. The equipment for the representative plants are listed below:

TABLE VIII-6
COSTS FOR FERRICYANIDE BLEACH REGENERATION BY OZONATION

Plant Size	A	B	C	D
Typical Annual Production (Film Only), 1,000 sq m/year (1,000 sq ft/year)	3.5 (37.5)	8.1 (87.5)	35 (375)	174 (1,875)
1977 Dollars				
Capital Investment Required	21,400	21,400	25,500	33,500
Annual Costs:				
Capital Recovery	4,300	4,300	5,100	6,700
Operating and Maintenance	3,400	3,400	3,400	3,400
Energy and Power	10	20	100	500
Total	7,710	7,720	8,600	10,600
Annual Resource Recovery	1,100	2,500	10,900	54,500
Net Annual Cost (Benefit)	6,610	5,220	(2,300)	(43,900)

Pollutant Parameter, kg/1,000 sq m	Effluent Without Treatment	Effluent With Treatment
Cyanide, Total	22	4.8

A and B plant - batch system

ozone generator
ozone monitor
pH control
pump
50-gallon tank

C and D plant -
continuous on-line system

ozone generator
ozone monitor
pH control
pump
100-gallon tank
automatic controls

The ozone generator was costed by selecting the nearest larger size commensurate with the plant ozone requirements based on the amount of film processed using ferricyanide bleach. The ozone requirement was related to production as stated in process specifications.

Operating costs are based on the costs given for a "typical" plant using ozone regeneration in a film processor's publication. Energy and power costs for the representative plants are based on a power requirement of 10 kwh per 0.45 kg (1 lb) of ozone generated, an ozone amount of 2.4 kg/1,000 sq m (0.48 lb/1,000 sq ft), and a power cost of \$0.05 per kwh. Annual resource recovery benefit was based on chemical savings between a plant using regeneration as compared to a plant discharging the spent bleach.

Ferrous Sulfate Precipitation of Ferricyanide

The costs established in this section are for a system to cause the precipitation of ferricyanide bleach carryover from waste fix. The costs, as determined for the representative plants, are shown in Table VIII-7.

TABLE VIII-7
COSTS FOR FERROUS SULFATE PRECIPITATION OF FERRICYANIDE FROM WASTE FIX

Plant Size	A	B	C	D
Typical Annual Production (Film Only) 1,000 sq m/year (1,000 sq ft/year)	3.5 (37.5)	8.1 (87.5)	35 (375)	174 (1,875)
1977 Dollars				
Capital Investment Required	4,600	6,500	9,200	22,200
Annual Costs:				
Capital Recovery	920	1,300	1,830	4,400
Operating and Maintenance	600	1,220	4,490	21,400
Energy and Power	10	20	60	300
Total	1,530	2,540	6,380	26,100
Annual Resource Recovery	—	—	—	—
Net Annual Cost (Benefit)	1,530	2,540	6,380	26,100

Pollutant Parameter, kg/1,000 sq m	Effluent Without Treatment	Effluent With Treatment
Cyanide, Total	4.8	1.3

Specific Costing References and Rationale for Ferrous Sulfate Precipitation

The equipment required for ferrous sulfate precipitation of ferricyanide from waste fix is based on the equipment used by plant 4550 which includes pumps, tanks, and mixers. The equipment was sized for the representative plants according to their relative production compared to plant 4550. The capital investment was determined from individual equipment costs provided by suppliers. Related capital investment costs such as engineering, drafting, mechanical installation, and electrical work were determined from the following relationship:

$$CN = C r \exp 0.6$$

where:

- CN = capital investment for representative plant, dollars
- C = capital investment incurred by plant 4550, dollars
- r = production ratio of representative plant to plant 4550.

Operating and maintenance and power costs for the representative plants were assumed to be directly proportional to these costs for plant 4550.

Evaporation and Associated Technologies to Reduce the Discharge of Process Wastewater to a Minimum

Costs were derived for the reduction of process wastewater discharge to a minimum from information supplied by plant 7781 which is currently using the technology. The technology, using a number of techniques as described in Section VII to minimize the hydraulic load, utilizes multi-stage evaporation to reduce wastewater discharge. The costs, as determined for representative plants, are shown in Table VIII-8.

TABLE VIII-8
COSTS FOR REDUCTION OF PROCESS WASTEWATER TO A MINIMUM
BY ADVANCED CONTROLS PLUS MULTI-STATE EVAPORATION

Plant Size	A	B	C	D
Typical Annual Production, 1,000 sq m/year (1,000 sq ft/year)	35 (375)	81 (875)	350 (3,750)	1,740 (18,750)
1977 Dollars				
Capital Investment Required	103,000	155,000	239,000	406,000
Annual Costs:				
Capital Recovery	20,500	30,800	47,600	80,800
Operating and Maintenance	21,000	21,000	43,100	74,700
Energy and Power	400	400	1,800	8,700
Total	41,900	52,200	92,500	164,200
Annual Resource Recovery	4,200	9,900	42,400	212,000
Net Annual Cost (Benefit)	37,700	42,300	50,100	(47,800)

Specific Costing References and Rationale for the
Reduction of Process Wastewater to a Minimum

Specific capital investment, operating, energy and power and annual resource recovery benefit costs were supplied by plant 7781. The information included costs for reverse osmosis treatment of wash water, developer regeneration by ion exchange, evaporation, and the reduction of ammonia in the condensate.

The capital investment costs were estimated by plant 7781 for the representative plants. Costs for special analytical equipment required for process control are included. The equipment includes a spectrophotometer and an atomic adsorption spectrometer.

The remainder of the costs for the representative plants were derived by linear scaling of the actual costs incurred by plant 7781. Labor costs for a full time analytical chemist was added to the operating costs. This cost is based on a salary of \$20,000 per annum, 3 shifts per day in the D plant, 2 shifts per day in the C plant and 1 shift per day in the A and B plants.

Treatment of Dichromate Bleach Wastes

Treatment technologies, along with the associated costs, have been established for the electroplating industry for reduction of the quantity of chromium in wastewater. The technology includes the chemical reduction of hexavalent chromium, pH adjustment for chromium precipitation, and diatomaceous earth filtration. It is recommended that these technologies be applied to after-dichromate bleach wash water mixed with the bleach overflow.

The costs are given in Tables VIII-9 through VIII-12. These costs were available in terms of flow. Film production levels comparable to these flows are included in the tables. This determination is based on an after-bleach wash water flow of 38 liters per minute (10 gallons per minute) and a film processing rate of 173 square meters per hour (1,865 square feet per hour).

TABLE VIII-9
CONTROL AND TREATMENT COSTS FOR HEXAVALENT CHROMIUM
REDUCTION - BATCH TREATMENT

Flow, liters/hour	189	379	1,893
Annual Film Production, 1,000 sq m/year (1,000 sq ft/year)	72 (780)	140 (1,500)	720 (7,750)
1977 Dollars			
Capital Investment Required	8,493	9,535	14,405
Annual Costs:			
Capital Cost	541	608	919
Operating and Maintenance	155	295	1,415
Energy and Power	256	256	256
Depreciation	1,699	1,907	2,881
Net Annual Cost (Benefit)	2,651	3,066	5,471

TABLE VIII-10
CONTROL AND TREATMENT COSTS FOR HEXAVALENT CHROMIUM
REDUCTION - CONTINUOUS TREATMENT

Flow, liters/hour	3,785	7,570	18,925
Annual Film Production 1,000 sq m/year (1,000 sq ft/year)	1,400 (15,100)	2,900 (31,200)	7,200 (77,500)
1977 Dollars			
Capital Investment Required	20,416	21,538	24,003
Annual Costs:			
Capital Cost	1,303	1,374	1,531
Operating and Maintenance	1,086	1,375	2,089
Energy and Power	256	256	256
Depreciation	4,083	4,308	4,801
Net Annual Cost (Benefit)	6,728	7,313	8,677

TABLE VIII-11
CONTROL AND TREATMENT COSTS FOR pH ADJUSTMENT (CHROMIUM TREATMENT)

Flow, liters/hour	492	4,921	49,205
Annual Film Production 1,000 sq m/year (1,000 sq ft/year)	190 (2,040)	1,900 (20,400)	19,000 (204,000)
1977 Dollars			
Capital Investment Required	1,452	4,921	18,855
Annual Costs:			
Capital Cost	93	314	1,203
Operating and Maintenance	286	1,036	3,758
Energy and Power	8	79	1,503
Depreciation	290	984	3,771
Net Annual Cost (Benefit)	677	2,413	10,315

TABLE VIII-12
CONTROL AND TREATMENT COSTS FOR DIATOMACEOUS EARTH
FILTRATION (CHROMIUM TREATMENT)

Flow, liters/hour	189	4,731	47,313
Annual Film Production 1,000 sq m/year (1,000 sq ft/year)	72 (780)	1,800 (19,400)	18,000 (194,000)
1977 Dollars			
Capital Investment Required	8,823	27,707	62,819
Annual Costs:			
Capital Cost	563	1,768	4,008
Operating and Maintenance	3,936	6,046	29,872
Energy and Power	22	302	1,970
Depreciation	1,765	5,541	12,564
Net Annual Cost (Benefit)	6,286	13,657	48,414

NON-WATER QUALITY ASPECTS

It is important to consider the impact of each treatment process on air, noise, solid waste, and radiation pollution of the environment to recognize and avoid the potential development of an adverse environmental impact upon these other media.

None of the control or treatment technologies considered for the photoprocessing industry have any known potential for air, noise, or radiation pollution exterior to the plant. There could be possible in-plant air pollution problems from the use of ozone or improper use of sulfide precipitation compounds. Proper use and monitoring equipment will control any potential hazard to plant personnel. Ozonation generators and reverse osmosis units create high but non-hazardous noise levels in the area close to the equipment. This problem can be alleviated with proper location and enclosure of the equipment.

The major potential non-water environmental impact from this industry is the potential generation of solid wastes. Solids generated from silver recovery are not a problem because of the obvious economic recovery value of the silver. Waste sludge from the precipitation of ferrocyanide wastes presents a solid waste disposal problem. One multi-plant company processes this sludge at a central location to reclaim the ferricyanide. Plants which do not reprocess this sludge will have to dispose of the solid waste in an approved landfill or other environmentally acceptable manner. Solid wastes generated from the treatment of waste dichromate bleach have no known market. These wastes must be disposed of in an approved landfill or other environmentally acceptable manner. Solid wastes are also generated from the plant using evaporation to eliminate process water discharge. The plant reports that the silver content is high enough to make it acceptable to a smelter for silver reclamation.

SECTION IX

ACKNOWLEDGMENTS

The Environmental Protection Agency was aided in the preparation of this Guidance Document by Versar Inc. Versar's effort was managed by Mr. Edwin Abrams with Mr. Lawrence G. Davies serving as principal investigator.

Mr. Richard Kinch and Mr. John Newbrough of the EPA's Effluent Guidelines Division served as Project Officers during the preparation of this document. Mr. Robert Schaffer, Director, Effluent Guidelines Division, and Mr. Gary E. Stigall, Branch Chief, Effluent Guidelines Division, Inorganic Chemicals Branch, offered guidance and suggestions during this project.

Appreciation is extended to the National Association of Photographic Manufacturers, Inc. and the individual companies and plants that participated in and contributed data for the formulation of this document.

SECTION X

BIBLIOGRAPHY

American National Standard: Dimensions of Aerial Film Spools. American National Standards Institute, Inc., New York, New York, 1972.

American National Standard: Dimensions for Film in Rolls for Phototypesetting or Photocomposing Devices, or Both. American National Standards Institute, Inc., New York, New York, 1972.

American National Standard: Dimensions for Graphic Arts Sheet and Roll Films. American National Standards Institute, Inc., New York, New York, 1973.

American National Standard: Dimensions for Industrial Radiographic Sheet and Roll Films. American National Standards Institute, Inc., New York, New York, 1973.

American National Standard: Dimensions for 135-size Film Magazines and Film for 135-size Still-Picture Cameras. American National Standards Institute, Inc., New York, New York, 1976.

American National Standard: Dimensions for Photographic Films in Rolls for Recording Instruments and Miscellaneous Uses. American National Standards Institute, Inc., New York, New York, 1973.

American National Standard: Dimensions for Professional Sheet and Roll Films. American National Standards Institute, Inc., New York, New York, 1973.

American National Standard: Dimensions for Unperforated and Perforated Photographic Film in Rolls, Including Leaders and Trailers, for Aerial and Related Uses. American National Standards Institute, Inc., New York, New York, 1976.

American National Standard: Specifications for Photographic Film for Archival Records, Silver-Gelatin Type, on

X/1
248

Polyester Base. American National Standards Institute, New York, New York.

American National Standard: Specifications for Photographic Film for Archival Records, Silver-Gelatin Type, on Cellulose Ester Base. American National Standards Institute, New York, New York.

American National Standard: Test Method for the Determination of Ferro- and Ferricyanide in Photographic Processing Effluents. American National Standards Institute, Inc., New York, New York, 1976.

Arthur D. Little, Inc. Economic Analysis of Interim Final Effluent Guidelines for the Photographic Processing Industry. U.S. Environmental Protection Agency, April 1976.

Bard, C. C., J. J. Murphy, D. L. Stone, and C. J. Terhaar. Silver in Photoprocessing Effluents. Journal of Water Pollution Control Federation, 48(2):389-394, 1976.

Bober, Thomas W. and Thomas J. Dagon. Ozonation of Photographic Processing Wastes. Journal of Water Pollution Control Federation, 47(8):2114-2129, 1975.

Buyers, Archie G., et al. Development and Application of Ion Exchange Silver Recovery System. University of New Mexico, Albuquerque, New Mexico, May 1974. 72 pp.

Carroll, John S. Amphoto Lab Handbook. American Photographic Book Publishing Company, Inc., New York, New York, 1970.

Color Print. Modern Photography, 43(2):92-93, 118-121, 124, 134-142, 176, 1979.

Cooley, Austin C. Regeneration and Disposal of Photographic Processing Solutions Containing Hexacyanoferrate. Journal of Applied Photographic Engineering, 2(2):61-64, 1976.

Cooley, Austin C. and Thomas J. Dagon. Current Silver Recovery Practices in the Photographic Processing

x-2
249

Industry. Journal of Applied Photographic Engineering, 2(1):36-41, 1976.

CPAC - Pollution Abatement Division. Wastewater Control Program for: Naval Intelligence Support Center. No. N62477-74-C-0308, Leicester, New York. 70 pp.

Dagon, Thomas J. Biological Treatment of Photo Processing Effluents. Journal of Water Pollution Control Federation, 45 (10):2123-2135.

Dagon, Thomas J. Processing Chemistry of Bleaches and Secondary Processing Solutions and Applicable Regeneration Techniques. Journal of Applied Photographic Engineering, 2(1):42-45, 1976.

Daignault, Louis G. Pollution Control in the Photoprocessing Industry through Regeneration and Reuse. Journal of Applied Photographic Engineering, 3(2):93-96, 1977.

Degenkolb, David J. and Fred J. Scobey. Handling and Control of Chemicals in a Modern Motion-Picture Laboratory. Journal of the Society of Motion Picture and Television Engineers, 81(6):465-469, 1972.

Degenkolb, David J. and Fred J. Scobey. Monitoring the Processing Chemical Costs and Effluents of a Motion-Picture Processing Laboratory. Journal of the Society of Motion Picture and Television Engineers, 84:599-603, 1975.

Degenkolb, David J. and Fred J. Scobey. Silver Recovery from Photographic Wash Waters by Ion Exchange. Journal of the Society of Motion Picture and Television Engineers, 86(2):65-68, 1977.

Battelle Columbus Laboratories. Development Document for Interim Final Effluent Limitation Guidelines and Proposed New Source Performance Standards for the Metal Finishing Segment of the Electroplating Point Source Category. EPA-440/1-75/040a, U.S. Environmental Protection Agency, Washington, D.C. April 1975. 235 pp.

x/3
250

Development Document for Proposed Existing Source Pretreatment Standards for the Electroplating Point Source Category. EPA-440/1-78/085, U.S. Environmental Protection Agency, February 1978. 532 pp.

Eastman Kodak Company. Aerobic Photodegradation of X(N) Chelates of (Ethylenedinitrilo) Tetraacetic Acid (EDTA). Environmental Science and Technology, 9(12):1035-1038, 1975.

Eastman Kodak Company. Data Release. No. J-9X. Rochester, New York, 1978. 2 pp.

Eastman Kodak Company. Kodak Photographic Products, 1975-1976. Rochester, New York, 1976.

Eastman Kodak Company. 1976 Index to Kodak Information. No. L-5. Rochester, New York, 1976. 46 pp.

Eastman Kodak Company. Sampling and Flow-Measurement Methods. No. J-50. Rochester, New York, 1976. 27 pp.

Eastman Kodak Company. Silver Recovery with Kodak Chemical Recovery Cartridge Type P. No. J-9. Rochester, New York, November 1979.

Eastman Kodak Company. "Low-Flow Prewash" Means Print Stability Compromise, Current Information Summary, September 1979. CIS-25. Rochester, New York.

Eastman Kodak Company. Silver Recovery with the Kodak Chemical Recovery Cartridge Type 3, January 1980, J9A. Rochester, New York.

Eastman Kodak Company. Recovering Silver from Photographic Materials, March 1980, J10. Rochester, New York.

Eastman Kodak Company. Potential Silver Yield from Photographic Products, December 1979, J10A. Rochester, New York.

Eastman Kodak Company. Disposal of Photographic Processing Effluents and Solutions, January 1973, J-28. Rochester, New York.

X/4
251

- Eastman Kodak Company. BOD₅ and COD of Kodak Photographic Chemicals, December 1973, J-41. Rochester, New York.
- Eastman Kodak Company. The Regeneration of Ferricyanide Bleach Using Ozone, September 1974, J-43. Rochester, New York.
- Eastman Kodak Company. In Support of Clean Water - Disposing of Effluents from Film Processing, September 1979, J-44. Rochester, New York.
- Eastman Kodak Company. The Filter Press for the Filtration of Insoluble Photographic Processing Wastes, January 1973, J-45. Rochester, New York.
- Eastman Kodak Company. The Biological Treatment of Photographic Processing Effluents, August 1975, J-46. Rochester, New York.
- Eastman Kodak Company. Chemical Composition of Photographic Processing Solutions, April 1975, J-47. Rochester, New York.
- Eastman Kodak Company. Silver in Photoprocessing Effluents, July 1976, J-51. Rochester, New York.
- Eastman Kodak Company. Disposal of Photographic Processing Solutions for the Small User, 1976, J-52. Rochester, New York.
- Eastman Kodak Company. The Use of Water in Photographic Processing, March 1978, J-53. Rochester, New York.
- Eastman Kodak Company. Water Conservation in Photographic Processing, July 1973, S-39. Rochester, New York.
- Eastman Kodak Company. Using Kodak Ektaprint 2 Bleach-Fix and Replenisher NR in Continuous Color Print Processors. Data Release Z-122G, Revised March 1980. Rochester, New York.
- Encyclopedia of Chemical Technology, Second Edition, Vol. 15. Wiley, New York, New York, 1968. pp. 371-389.

X/5

252

- Ericson, Franklyn A. Effluent Sampling and Flow Measurement for the Photoprocessor. Journal of Applied Photographic Engineering, 2(2):51-60, 1976.
- EROS Data Center. Processing Information for EROS Data Center Waste Treatment System. No. OPL4-7. U.S. Geological Survey, 1975.
- An Evaluation of the Mead Technology Laboratories Aqua-Fix Waste Disposal System. Directorate of Avionics Engineering, Wright-Patterson AFB, Ohio, August 1976.
- Fatora, David A. Wash Water Recycling by Catalytic Oxidation of Thiosulfates and Sulfites. Journal of Applied Photographic Engineering, 2(4):227-228, 1976.
- Fields, Alfred E. Reducing Wash Water Consumption in Photographic Processing. Journal of Applied Photographic Engineering, 2(3):128-133, 1976.
- Focal Encyclopedia of Photography, Vol. I. Focal Press, New York, New York, 1965. pp. 278-281.
- Focal Encyclopedia of Photography, Vol. II. Focal Press, New York, New York, 1965. pp. 1672-1675, 1185-1187.
- Gale, Robert O., and Allan L. Williams. Factors Affecting Color Film Dye Stability: Relating Printing Problems and Release Print Quality, Journal of the SMPTE, Vol. 72, October 1963. pp. 804-809.
- SPSE Handbook of Photographic Science and Engineering. Woodlief Thomas, Jr., ed. Wiley-Interscience, New York, New York, 1973. pp. 609-622.
- Haderer, P. A. and J. A. Defilippi. Reducing Photoprocessing Wastes through Reuse and Recycling. Industrial Photography, June 1977. pp. 22-23, 42-45.
- Hendrickson, Thomas N. The Zero-Discharge Law and the Motion-Picture Film Processing Industry. Journal of the Society of Motion Picture and Television Engineers, July 1973.

x/6
253

- Hendrickson, Thomas N. and Louis G. Daignault. Treatment of Complex Cyanide Compounds for Reuse or Disposal. EPA-R2-73-269, U.S. Environmental Protection Agency, Washington, D.C., June 1973. 151 pp.
- Image Technology. Journal of Applied Photographic Engineering, 4(2):93-96, 1978.
- In-Process Pollution Abatement. EPA 625/3-73-002, U.S. Environmental Protection Agency Technology Transfer Seminar Publication, July 1973. 69 pp.
- Iwano, H., T. Hatano, S. Matsushita, and K. Shirasu. Regeneration of Ferric-EDTA-Thiosulfate Bleach-Fix Solution by Anion-Exchange Resins. Journal of Applied Photographic Engineering, 2(2):65-69, 1976.
- Johnson, D. W. Precipitation Techniques. Publication reference unknown. 17 pp.
- Kennedy, David C. Prediction of Ion-Exchange Sorption of Metal Ions from Complex Ion Formation Data. Presented at 171st National ACS Meeting, New York, New York, April 1976. 32 pp.
- Kennedy, David C., Mark A. Kimler, and Carol A. Hammer. Functional Design of a Zero-Discharge Wastewater Treatment System for the National Center for Toxicological Research. Presented at the 31st Annual Purdue Industrial Waste Conference, May 1976. 19 pp.
- Kleppe, J. Wesley. Practical Application of an Ion Exchange Method for Color-Developer Reuse. Journal of the SMPTE, 88:168-170. March 1979.
- Kleppe, J. Wesley. The Application of an Ion Exchange Method for Color Developer Reuse, Journal of Applied Photographic Engineering, Vol. 5, No. 3, Summer 1979. pp. 132-135.
- LaPerle, Robert L. Removal of Metals from Photographic Effluent by Sodium Sulfide Precipitation. Journal of Applied Photographic Engineerins, 2(3):134-146, 1976.

- Lorenzo, George A. and Michael A. Claprood. Treatment of Photographic Wash Waters for Reuse or Disposal. Presented at SPSE 14th Annual Fall Symposium, Washington, D.C., October 1974. 20 pp.
- The Manufacture and Use of Selected Inorganic Cyanides, Task III. EPA 560/6-75-012, U.S. Environmental Protection Agency, Washington, D.C., January 1976. 213 pp.
- Mees, C. E. Kenneth. The Theory of the Photographic Process. The Macmillan Company, New York, New York. pp. 1047-1087.
- Mina, R. Silver Recovery from Photographic Effluents By Ion-Exchange Methods. Presented at the SPSE Symposium on Photofinishing in the 1980's, March 21, 1980.
- National Association of Photographic Manufacturers, Inc. American National Standard on Photographic Processing Effluents. Harrison, New York, April 1975. 42 pp.
- National Association of Photographic Manufacturesr, Inc. Survey Form. May 1976. 23 pp.
- Oregon State University. Toxicity to Fish of Cyanides and Related Compounds: A Review, U.S. Department of Commerce, April 1976. PB 253-528.
- Owerbach, Daniel. The Instability of Free Cyanide in Photographic Processing Effluents. Journal of Applied Photographic Engineering, 4(2):72-76, 1978.
- Pathways of Photoprocessing Chemicals in Publicly Owned Treatment Works. National Association of Photographic Manufacturers, Inc. 1977. 91 pp.
- Photo Film Achieves Zero Waste Discharge. Chemical and Engineering News Magazine, July 1978.
- Photographic Processing Effluent Control. Journal of Applied Photographic Engineering, 4(2):62-71, 1978.
- Photo Processing Sludge: New Comstock Lode? Sludge Magazine, January-February 1979. pp. 22-26.

Ryckman/Edgerley/Tomlinson and Associates, Inc.
Treatability and Functional Design of a
Physical-Chemical Wastewater Treatment System for
Printing and Photodeveloping Plant. Presented at the
31st Annual Purdue Industrial Wastewater Conference,
West Lafayette, Indiana, May 1976. 23 pp.

Shemesh, Alvin and Norman Ackerman. Medical Hazards of
Photography. Industrial Medicine and Surgery,
33:807-812, 1964.

Sittig, Marshall. Pollutant Removal Handbook. Noyes Data
Corporation, Park Ridge, New Jersey, 1973. pp. 155-163,
462-465.

Supplement B: Volumes I, II and III. Guardian, Berkey and
Kodak Data, Effluent Limitations Guidelines and
Miscellaneous data and references. 1974.

Supplement B: Volume IV, Parts 1 and 2. Industry Survey
Data. 1974.

Supplement B: Volume V, Parts 1 and 2. References. 1974.

Supplement B: Volume VI, Parts 1 and 2. NPDES permits and
applications. Additional discharge permits and
applications. 1974.

Supplement B: Volumes VII and VIII. NAPM, Environmental
Effect of Photoprocessing Chemicals, Volumes I and II,
Harrison, New York, 1974.

U.S. Air Force. Recovery of Silver from Expended
Photographic Material. No. F42600-73-D-1463. May 1972.

U.S. Department of Commerce. 1972 Census of Selected
Service Industries. August 1975, September 1975,
December 1975.

U.S. Environmental Protection Agency. Pretreatment
Standards for Ammonia, Phenols and Cyanides. March
1976. 142 pp.

X-9
256

Waste Treatment. EPA 625/3-73-002, U.S. Environmental Protection Agency Technology Transfer Seminar Publication, July 1973. 47 pp.

West, Lloyd E. Water Quality Criteria. Photographic Science and Engineering, 9(6):398-413, 1965.

Westin, R. F. Development Document for Interim Final Effluent Limitations, Guidelines and Proposed New Source Performance Standards for the Photographic Processing Subcategory. U.S. Environmental Protection Agency, Washington, D.C., June 1976.

Wolfman, Lydia. 1975-1976 Wolfman Report on the Photographic Industry in the United States. ABC Leisure Magazines, Inc., New York, New York, 1976. 96 pp.

A Zero Discharge Wastewater Treatment System. Environmental Science and Technology, 12(9):1004-1006, 1978.

SECTION XI

GLOSSARY

- aeration: The addition of air to a liquid. This is done by pumping the liquid into the air or by bubbling air through it via sparging tubes. Aeration is used as part of the ferric EDTA bleach regeneration process in photographic processing. It can be used for reduction of oxygen demand in wastewater.
- acid rinse: A solution, usually dilute acetic acid, used as a stop bath following development.
- anion: The ion in an electrolyte which carries the negative charge and migrates toward the anode under the influence of a potential difference.
- automatic wash water controls: Automatic solenoid operated shutoff devices which completely stop the flow of water into the processor when it is not being used, thereby avoiding excessive wash water flows.
- biochemical oxygen demand (BOD₅): A measurement of the amount of dissolved oxygen an effluent will consume from water over a five-day period of time.
- biodegradable: A substance capable of being broken down by organisms into simpler entities.
- black and white film: This film consists of a support, usually a plastic film which is coated with a light sensitive emulsion and an outer protective layer. The emulsion is adhered to the supporting base with a special layer called a sub. The emulsion contains: gelatin, silver salts of bromide, iodide, chloride, sensitizers, hardeners, and emulsion plasticizers.
- bleach-fix or blix: A solution used in some color processing that functions both as a bleach and as a fix.
- bleach: A step in color film processing whereby the silver image is converted back to silver halides.

cation: The ion in an electrolyte which carries the positive charge and which migrates toward the cathode under the influence of a potential difference.

chelating agents: A class of chemical compounds that can form complex chemical species. Some of the compounds are used as bleaching agents when complexed with ferric ions and as sequestering agents in the isolation and removal of metallic ions.

chemical oxygen demand (COD): An analytical method for measuring the oxygen demand of an effluent. This method is faster than the BOD₅ test and responsive to a broader range of components.

chemical prewash: A salt bath between the fix and final wash which chemically removes the fix from the emulsion at a faster rate than can be done by washing, thereby reducing the after-fix wash water time and volume.

chlorination: The addition of chlorine to wastewater to cause breakdown of certain compounds by oxidation.

chromium: A metallic element whose compounds are used in some photographic processes as bleaching or hardening agents.

clarification: The process of removing turbidity and suspended solids by settling.

clearing bath: A processing solution that removes most residual fixer from processed film or paper prior to washing, minimizing the water requirement.

color couplers: A group of organic chemicals which react with the oxidized components of the developers to form color dyes. They are either incorporated in the film emulsion at the time of manufacture or they are included in the color developing solution.

color film: Color film has three separate light sensitive emulsion layers, which after inclusion of the appropriate sensitizing dyes, record an image of the blue light components on one layer, the green light

components on another, and the red light components on the third layer.

color reversal (DC) process: A color reversal film process in which the color couplers are added during development.

color reversal (IC) process: A color reversal film and paper process in which the color couplers which form the color dye image are incorporated into the emulsion layers at the time of manufacture.

complex cyanide: This term refers to a complex ion containing cyanide ions and a cation such as iron, e.g., ferrocyanide $[\text{Fe}(\text{CN})_6]^{-4}$ and/or ferricyanide $[\text{Fe}(\text{CN})_6]^{-3}$.

conservation: Methods applied to make maximum use of processing chemicals and water and to keep the quantity of effluent discharged to a minimum.

continuous length processor: An automatic processing machine whereby long rolls of film or paper are fed into successive photoprocessing tanks via a series of appropriate crossover connections between racks. The starting end of the material to be processed is attached to a leader which guides the material through the machine.

conventional silver recovery: The use of metallic replacement or electrolytic methods or both for the recovery of silver from fix solutions.

countercurrent washing: A method of washing film or paper using a segmented tank system in which water is cascaded progressively from one tank segment to the next counter to the movement of the film or paper.

develop: A step in photoprocessing whereby the latent image is made visible in a developer solution.

developer: A chemical processing solution containing a developing agent. This solution converts the exposed portions of the photographic emulsion to silver, creating images of metallic silver.

developing agents: These photographic materials usually are aromatic compounds with phenolic or amino electron-donor groups arranged ortho or para with respect to each other, such as: hydroquinone, methyl p-amino-phenol (metol), or 1-phenol-3 pyrazolidone (phenidone).

dichromate bleach: A bleach used in some black and white reversal and color film processing.

dip and dunk: An automatic processing machine whereby strips of film are "dipped" into successive photoprocessing tanks and held for the appropriate time.

direct discharge: The discharge of wastewater to waters of the United States.

dissolved solids: Solid matter in effluent that will not settle out or separate with filtration.

drag-in: Water or solution carried into another solution by the film or paper being processed.

drag-out: Water or solution carried out of the processing tank by the film or paper being processed.

dry: The final processing step which involves drying the photographic film or paper in a dust-free atmosphere.

dye image: A color image formed when the oxidized developer combines with the color couplers.

EDTA (ethylenediaminetetraacetic acid): A chelating compound used in some bleach and bleach-fix solutions. It is also used in other solutions to sequester some ions present in hard water.

effluent: Liquid waste leaving its source.

electrolytic silver recovery: The removal of silver from silver-bearing solutions by application of a direct current to electrodes in the solution causing metallic silver to deposit on the cathode.

elution: (1) The process of washing out, or removing with the use of a solvent. (2) In an ion exchange process it

is defined as the stripping of adsorbed ions from an ion exchange resin by passing through the resin solutions containing other ions in relatively high concentrations.

equalization: The collection of wastewater in tanks or ponds for the purpose of equalizing or controlling the flow quantities prior to discharge or other treatment steps.

evaporation: A technique used to concentrate solids by removing water resulting in a quantity of concentrated waste containing the solids.

ferricyanide: This ion, usually in the form of potassium ferricyanide, is used as a bleach for oxidizing metallic silver to ionic silver in some color processes. Ferricyanide is reduced to ferrocyanide as it oxidizes silver in the film emulsions.

ferricyanide bleach: A processing solution containing the ferricyanide ion. This is used to convert metallic silver to ionic silver, which is removed in the fixing step.

ferrocyanide: The ion that results when ferricyanide oxidizes silver or reacts with various reducing agents.

filtration: The passing of wastewater through solid or particulate media to reduce the suspended solids.

fix: A step in photoprocessing whereby the silver halides are removed from the emulsion using a solvent such as sodium thiosulfate.

flocculation: The addition of a chemical, such as alum, ferric chloride or polymeric electrolytes, that promotes coagulation of suspended particles, thereby increasing settling rates and improving separation.

gas-burst agitation: This is the most common method of automatic agitation found in automatic processing machines. Gas is released at controlled intervals through tiny holes in a distributor plate in the bottom of the solution tank. The gas bubbles formed during release provide the random agitation pattern necessary for uniform results.

harden: This photoprocessing step serves to check emulsion swelling and raise the melting point for the emulsion to allow for drying at a higher temperature.

hardener: A chemical present in some photographic solutions that reacts with gelatin in the emulsion to protect the film from damage during or after processing. Common hardeners are potassium aluminum sulfate, potassium chromium sulfate, and formaldehyde solution.

ion: An atom or group of atoms possessing an electrical charge.

ion exchange: A reversible interchange of ions between a liquid and a solid involving no radical change in the structure of the solid. The solid can be a natural zeolite or a synthetic resin, also called poly-electrolyte. Cation exchange resins exchange their hydrogen ions for metal cations in the liquid. Anion exchange resins exchange their hydroxyl ions for anions such as nitrates in the liquid. When the ion-retaining capacity of the resin is exhausted, it must be regenerated. Cation resins are regenerated with acids and anion resins with bases.

low flow prewash: A system which concentrates most of the fix carryout in a low volume after-fix prewash tank. The system consists of segmenting the after-fix prewash tank to provide a small prewash section with separate wash water make-up and overflow.

metallic replacement: This occurs when a metal such as iron comes in contact with a solution containing dissolved ions of a less active metal such as silver. The dissolved silver ions react with solid metal (iron). The more active metal (iron) goes into solution as an ion and ions of the less active metal become solid metal (silver).

NAPM: National Association of Photographic Manufacturers, Inc.

National Pollutant Discharge Elimination System (NPDES): The Federal mechanism for regulating point source discharges by means of permits.

navigable waters: See waters of the United States.

negative process: A process which yields a negative image on film or paper of the original subject.

neutralization: The adjustment of the pH of a waste stream with acid or alkali to produce a near neutral condition.

non-process water: Water used for the heating and cooling of process solutions to maintain proper operating conditions or for the make-up water in cooling towers, boilers and lawn sprinkling systems. This water is not process water as it does not come in contact with raw materials or the product.

POTW: Publicly owned treatment works (45 FR 33423).

NPDES: See National Pollutant Discharge Elimination System.

on-site treatment: Treatment of effluent performed at its source, prior to discharge into a sewage system or a receiving body of water.

oxidation: The conversion of chemical substances to higher oxidation states through loss of electrons. In waste treatment, oxidation usually is involved in the breakdown of many substances.

ozonation: The process of using ozone (O_3) as an oxidizing agent to oxidize and degrade chemical constituents in an effluent or to regenerate ferricyanide bleach.

ozone: A powerful gaseous oxidizing agent (O_3); it can be generated by a high voltage discharge across a stream of air or oxygen.

persulfate: A strong oxidizing agent used to regenerate ferrocyanide to ferricyanide in bleaches.

pH: A numerical value describing the acidity (low pH number) and alkalinity (high pH number) of a solution.

polyelectrolytes: Synthetic chemicals (polymers) used to speed the removal of solids from wastewater by causing suspended particles to coagulate. They can be anionic

[- charge, nonionic (+ and - charge) or cationic (+ charge)].

precipitation: The separation of a dissolved substance from its solution by rendering it insoluble through chemical reaction.

prehardener: A solution used to harden the emulsion in order to protect it from damage during processing.

primary treatment: The removal of material that floats or will settle in municipal sewage by using screens to catch the floating objects and tanks for the heavy matter to settle in. This treatment usually involves sedimentation and/or flocculation.

process water: Water used in washing film and paper, in making up photoprocessing solutions, in the washing and rinsing of mixing utensils, storage tanks, and processing machines, and in area washdown.

reclamation: The process of deriving usable materials from waste, by-products, etc., through physical or chemical treatment.

regeneration: The removal or reconstitution of by-products and the replacement of certain components of the processing solution being reclaimed.

Rem-Jet: A coating on the back of certain films for the reduction of light reflections during exposure. The rem-jet backing is removed during processing by washing or by washing and mechanical buffing.

reversal process: A process which yields a direct positive image of the subject on the same material used for the original exposure.

reverse osmosis: A separation technique used for recovering wash water that involves letting a wastewater stream flow under pressure through a semipermeable membrane. Most of the water molecules pass through the membrane as permeate and the pollutants remain behind as concentrate.

settling: The concentration of particulate matter in wastewater by allowing suspended solids to sink to the bottom.

short stop: A step in photoprocessing which follows development whereby the basic activators in the developer are neutralized to prevent further development.

silver halide: Silver halide is an inorganic salt of silver in combination with elements from Group 7A of the Periodic Table. Silver halide salts used in photography are silver chloride, silver bromide, and silver iodide. Upon exposure to light, silver halide crystals undergo an internal change making them capable of subsequent reduction to metallic silver by appropriate developing agents.

silver recovery: Removal of silver from used photographic processing solutions and materials so it can be made available for reuse.

spray washing: A method of washing film or paper using a spray rather than an immersion tank as a means of conserving water.

stabilizer: A chemical bath, usually the last in a processing cycle, that imparts greater life to a processed photographic film or paper through one of several preserving steps.

squeegee: A piece of flexible material or a thin stream of air set to impinge on one or both sides of photographic film or paper as it comes out of a tank of processing solution. This reduces the amount of solution carried over.

surface water: See waters of the United States.

suspended solids: Undissolved matter carried in effluent that may settle out in a clarifier.

total organic carbon (TOC): A measure of the amount of carbon in a sample originating from organic matter. The

test is run by burning the sample and measuring the carbon dioxide produced.

wash: A water wash is a step in photoprocessing removing residual processing chemicals absorbed in the emulsion or substrate.

waters of the United States: All waters which are currently used, used in the past, or may be used, for interstate or foreign commerce, including all waters subject to ebb and flow of the tide. Also includes intrastate lakes, rivers, streams, mud flats, and wetlands (44 FR 33300, 44 FR 33424).

zero discharge: A goal for 1985 as set by the Federal Water Pollution Act of 1972. This means that the discharge of pollutants into the navigable waters will be eliminated by 1985.

XI-XO

267

APPENDIX A
TELEPHONE CONTACT SURVEY MEMO

A-1

268

17 January 1977

Versar Inc., EPA Contract No. 68-01-3273
FILE MEMO - TELEPHONE CONTACT - PHOTO PROCESSING

Versar Engineer _____ Date _____
Time _____ File No. _____

Person Contacted:

Name _____ Title _____
Company _____ Address: Street _____
Phone _____ City _____ State _____
Zip Code _____

A. Process

1. What types of processes are used? still film% movie% paper%

(a) black and white: negative process _____
 reversal process _____
(b) color: negative process _____
 reversal (couplers in emulsion) _____
 reversal (couplers in developer) _____
(c) Other: _____
 explain _____

2. Are machine processes used? Yes _____ No _____ Partially _____
For which processes? _____

3. Is replenishment used? Yes _____ No _____ Partially _____ Continuous _____ Batch _____
Which processes? _____

4. Are chemical recovery and recycle methods used? Yes _____ No _____ Partially _____
(a) Silver recovery - Yes No Metallic Electro- Off- Recycle Discharge
 Replacement lytic site

From: Fix _____ % _____ %
bleach-fix _____ % _____ %
washwater _____ % _____ %

(b) Bleach regeneration: Yes _____ No _____ Partially _____
Ferryanide: Method _____
Processes used _____

Ferric EDTA: Method _____
Processes used _____

Other: _____

(c) Other (such as coupler, developer, etc. _____
Processes used _____

5. Use of squeegees: Everywhere recommended _____ Partial use _____ Not used _____
6. Estimated Process Water Usage: less than 1,000 gpd _____; 1,000 to 9,999 gpd _____;
10,000 to 99,999 gpd _____; more than 100,000 gpd _____.

7. Estimated production: less than 1,000 sq. ft./day _____; 1,000 to 2,999 sq. ft./
day _____; 3,000 sq. ft./day to 20,000 sq. ft./day _____;
more than 20,000 sq. ft./day _____.

B. Wastewater

1. Other than recovery or recycle, is process wastewater treated before
discharge? Yes _____ No _____

(a) If yes, how? _____

(b) Does the treated stream contain all the process wastewater? Yes _____ No _____

(c) Does the treated stream contain any non-process wastewater?

Sanitary _____ Non-contact cooling _____ Boiler _____ Other _____

2. Where are the wastewater streams discharged?

	<u>Contains</u>	<u>Discharged to</u>
Stream 001	_____	_____
Stream 002	_____	_____
Stream 003	_____	_____
	_____	_____

3. Do you have a discharge permit for any stream?

Stream(s) _____

	<u>Number</u>
_____ state	_____
_____ Corp.Eng.Appl.	_____
_____ NPDES	_____
_____ Other (POTW)	_____

What parameters are limited? _____

4. Is analytical data available and for what period of time?

No _____ Yes _____ Period _____

5. Are sewer user charges employed by local municipality? If so, what are charges and basis (flow, pollutant, etc.) _____

C. General

1. Comments: _____

2. Would the plant be agreeable to an engineering visit by an EPA Representative?

Who should be contacted _____

3. What type of customer or service provided?

(a) Amateur _____

(b) Professional _____

(c) Commercial (Art, printing, etc.) _____

(d) Commercial (Movie, T.V.) _____

(e) Studio (portrait, school) _____

(f) Other _____

4. Are toners used? _____

If so what type _____

APPENDIX B
LONG-TERM PLANT EFFLUENT DATA

B/1

272

LONG-TERM DATA FOR PLANT 6208

KEY: AG79: Effluent Silver Concentration, mg/liter,
mid-1974 to July 1979

CN79: Effluent Total Cyanide Concentration, mg/liter,
mid-1974 to July 1979

CR79: Effluent Total Chromium Concentration, mg/liter,
mid-1974 to July 1979

LIS .ZAISSE AG79

0.39	0.32	0.48	0.93	0.15	0.27	0.59	0.34	0.31	0.5
1.4	1.4	0.52	0.21	0.17	0.05	0.57	0.86	1.2	1.2
0.22	0.25	0.7	0.88	0.9	1.22	0.32	0.032	0.139	0.2
0.01	0.317	0.23	0.16	0.19	0.13	0.32	0.17	0.5A	0.22
0.38	0.43	0.48	1.2	0.08	0.53	0.33	0.2	0.92	0.14
0.14	0.94	0.5	0.2	0.16	0.16	0.17			

CN 79

0.005	0.005	0.005	0.008	0.005	0.005	0.029	0.005	0.006	0.005
0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
0.005	67.4*	0.06	0.005	0.005	0.01	0.005	1.8	0.01	0.28
0.14	0.01	0.26	0.14	0.21	0.01	0.032	0.104	1.75	0.04
0.08	1.12	0.01	0.57	0.01	0.01	0.04	0.01	0.01	0.08
0.01	0.01	0.01	0.01	0.01	0.01	0.01			

CR 79

3.09	4.73	3.11	5.93	3.56	4.59	4.11	3.6	2.4	0.2
3.0	2.7	1.84	2.8	2.91	4.38	5.9	4.8	4.4	5.4
8.1	4.4	4.2	3.31	6.4	3.06	8.2	0.46	1.82	1.0
1.76	4.55	0.6	0.24	0.35	2.92	1.25	3.82	5.0	2.0
1.1	2.6	4.1	3.4	0.8	3.7	6.6	2.3	6.2	3.1
2.6	5.0	2.1	4.3	2.8	4.7	2.3			

* Value not used.

B-2

273

LONG-TERM DATA FOR PLANT 7781

KEY: AG577: Effluent Silver Concentration, mg/liter,
1 February to 29 April 1977

AG877: Effluent Silver Concentration, mg/liter,
5 July to 1 August 1977

CD577: Effluent Cadmium Concentration, mg/liter,
1 February to 29 April 1977

CD877: Effluent Cadmium Concentration, mg/liter,
5 July to 1 August 1977

AG677									
6.31	5.10	5.27	9.75	4.64	8.64	13.12	7.93	7.26	7.94
7.50	8.10	4.44	3.28	2.33	4.46	2.36	3.15	4.33	3.70
5.76	8.46	7.46	3.03	4.34	2.72	1.40	1.97	2.46	6.20
5.60	8.00	2.85	6.10	9.27	15.10	14.68	5.78	4.23	2.91
11.66	10.34								
AG 877									
8.72	4.93	7.18	4.69	3.62	3.61	3.48	3.05	9.01	8.01
5.23	3.75	3.12	1.52	1.53	2.11	1.98	1.52	1.41	1.23
CD 577									
0.57	0.8	0.9	0.7	0.08	0.21	0.33	0.48	0.66	0.52
0.88	0.72	2.0	0.95	1.18	1.6	1.47	1.57	0.8	0.64
0.94	0.98	1.24	1.52	2.23	1.85	1.64	1.84	2.22	3.55
3.14	4.0	3.69	1.82	2.6	2.78	2.5	1.84	0.88	0.85
0.71	0.63	0.97	0.51	0.82	1.0	1.12	1.0	0.25	0.25
0.56	1.12	1.0	0.5	0.33	0.57	0.54	0.5	0.41	0.26
0.29	0.35	0.31	0.19						
CD 877									
0.18	0.19	0.24	0.18	0.1	0.09	0.09	0.11	0.17	0.22
0.2	0.15	0.12	0.04	0.04	0.04	0.05	0.06	0.02	0.05